ROADS and STREETS

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HALBERT P. GILLETTE, President and Editor
E. S. GILLETTE, Secretary
R. W. HUME, Vice-President
C. T. MURRAY, Managing Editor
FREDERIC KAMMANN II, Advertising Manager
Cleveland Office, 621 Hippodrome Bldg.: E. C. KELLY, Manager
New York Office, 415 Lexington Avenue: ERWIN T. EYLER, Eastern Manager

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The First Great Cooperative Inventor

Edison's 80th birthday has been the occasion of universal praise of his genius. Among the numerous comments and articles that were published Feb. 11, we saw none that mentioned what seems to us to be one of the great reasons for his success. We mean his systematic use of what may be called the principle of cooperative inventing.

For 50 years Edison has operated a laboratory at Menlo Park, and has employed a corps of inventive minds to assist him. We raise the question whether he is not, in fact, the first man to organize and operate a research laboratory. If so, his genius is the more remarkable, for to have created a new method that is applicable in all scientific fields is even greater than to have created the phonograph and all his other thousand novel devices.

Edison has never concealed the fact that he employs many inventive assistants; but, on the other hand, he has never said much about his indebtedness to them collectively or individually. Occasionally when one of them, like Festa, has left Edison's laboratory and has attained celebrity because of his own great ability, it has been made evident to the discerning that Edison is a cooperative inventor. But for some reason Edison has made no point of that fact, nor have the newspapers sensed its true significance.

On the other hand, the research laboratories of the General Electric Co., the American Telephone and Telegraph Co., and a few others, have received a great deal of publicity in recent years. In consequence it is now pretty generally known that cooperative inventing has accomplished marvels. But Edison's development of cooperative system of discovery and invention antedates the two just mentioned, and all others in this country, by many years.

Since the Edison laboratory was an evolution, rather than a sudden creation, it is not unlikely that he himself has not fully appreciated the importance of the new method of inventing—cooperative inventing—which he has apparently originated. This may account for his silence about it.

Unlike Luther Burbank, Thomas Edison has not been an expounder of his own methods. Burbank told the world just how he went about "inventing" and producing new plants. A 12-volume treatise and several articles have told the Burbank story. And that story is of even greater value than all of Burbank's achievements, for it has shown many others how to accomplish the same sort of thing. If Edison could be induced similarly to expound his methods, who can doubt the value of his "story"?

It is a mistake to assume that invention and discovery are unteachable. Burbank's book alone would suffice to expose that sort of error. Several generations ago John Herschel, the celebrated astronomer and scientist, wrote a book on the principles of scientific discovery, which will make the basis of his inductive logic; and there have been other noteworthy, although fragmentary, contributions to the art and science of discovering natural laws.

It should lie within Edison's ability to expound his own principles of inventing, and if this were done we doubt not that the principles of cooperative inventing would be found to be his most important discovery.

H P Gillette

Watch That Overrun!

One of the many reasons why costs tend to exceed the estimate is that additional cement and sand are often required because of faulty management of the paving operation. It is not unusual for overrun to average 6 per cent. Sometimes it has gone as high as 9 per cent. In one case that has been reported, where the cement overrun totaled 8.98 per cent, the causes were investigated. This examination revealed that the subgrade averaged ¼ in. below grade, accounting for an overrun of 3.45 per cent, that the bulking of sand so affected proportioning that it caused an overrun of 5.1 per cent, and that loss of cement due to lack of protection against dampness caused a further overrun of 0.44 per cent. This loss, on 720 ft. of 16-ft. road, involved a loss of 162 sacks of cement.

Overrun losses may be minimized by careful attention to several operations on the job. First of all, the contractor should protect himself by obtaining, if possible, a clause in the specifications that would make it possible for him to obtain reimbursement for the unavoidable expenditure of extra material.

Then, in any event, when he comes on the job he should see to it that rough grading has been well done and left just slightly above finished grade. In the fine grading operation, he will then need only to remove a small quantity of dirt, shaping the grade accurately without having to make any fills. Forms must be set carefully to line and grade, and braced to withstand the impacts and pressures incident to the work. Stakes driven to line and grade make good support for forms in soft soils.

Next, means must be taken to counteract the bulking effect of moisture in the sand by any means permitted in the specification. The final precaution is to see that the finishing machine is properly set to crown and grade, and that the concrete is so leveled out ahead of the machine that there will be no loss of material over the sides of the form.

When all these precautions are carefully observed, rehandling and stock piling of aggregates minimized, and cement protected from the elements, the losses due to overrun can be materially reduced. Good management pays well.

"State Roads Not Designed for Heavy Traffic"

To the Editor: Referring to the editorial in its February, 1927, issue of Roads and Streets, entitled "State Roads Not Designed for Heavy Traffic," I feel as though Governor Fisher was basically correct and that you were incorrect in your suggestion that we should follow the past performances of the railroads of this country in continuously overloading their roadbed with equipment heavier than for which the roadbed was designed, then placing the roadbed in condition to carry this heavy equipment upon the completion of this additional strength of roadbed, then overloading it again with heavier equipment. It is not a unanimous conclusion, by all observing engineers, that this policy has been a wise one on part of the railroads.

In the southwestern part of Michigan, during the past six months, we have been checking up on truck loads and have found that only one-tenth of one per cent of the automotive traffic is overloaded. I am of the opinion that the transportation truck companies should work out an economical trucking system of transportation to conform to the legal limits, which are plenty high enough at the present time, rather than the people of the several states should be taxed to build highways for the use and profit of only one-tenth of one per cent of users. It seems to me that this traffic must be regulated or there will set in a reaction that will dampen the public ardor for the immense expenditure of money for highway purposes.

In my opinion, the permissible truck loads in most states are reasonable, if not generous, and if the law is adhered to, we can serve ninety-nine and nine-tenths per cent of the people over pavements that have been designed and made during the past three or four years.

S. J. Stewart, Maintenance Supervisor, Southwestern Michigan.
Kalamazoo, Mich.

Using a Grader with Fresnos

Editorial in the Earth Mover

J. L. Harrison, a highway engineer connected with the United States Bureau of Public Roads, recently called attention to the economy in the use of a blade grader instead of a plow for loosening the ground in advance of fresno operation. Credit for the development of the innovation seems to belong to Mr. Davis of the Davis Construction Company, Booneville, Mo., he having been very successful in the use of the blade grader for loosening heavy soils for fresno operation. His outfit consists of a 5-ton crawler-type tractor and an 8-ft. blade grader.

In a general way, Mr. Harrison concludes, the direct cost of using a tractor and a blade grader is perhaps a third higher than the direct cost of using a standard plow team, and the justification for the substitution of such an outfit for the standard plow team must come from other benefits than a lower direct-cost. As a matter of fact these benefits are apparent when the operation of this outfit is studied.

Operation is simplicity itself. The blade is set out so that it will make an end cut about from 8 to 12 in. wide and of whatever depth, up to about 12 in., the conditions warrant. The blade is set at an angle of 45 degrees or more, so that as this prism is cut it is rolled along the blade, and deposited in a continuous pile at the open end of the blade. Rolling the material along the blade breaks up all lumps so that when the material leaves the blade it is well broken up and about as easy to load as light loam. It is, therefore, possible for a fresno to take a full load easily.

Another matter of importance cited is the fact that a smooth floor is maintained in the cut. New material is taken out only at the outer edge of the blade but in order to roll the material without loss, the blade has to be held right at the surface of the ground. Each passage of the machine, therefore, not only sweeps the floor of the cut clean, but insures that the windrow of loosened material will lie on a floor which is so smooth that it can be picked up without the danger of the fresno catching on a rough spot. The full load is, therefore, taken with no heavy strain on the stock. Indeed it is apparent at once that loading—commonly a heavy strain on the stock—is not particularly more difficult than hauling to the dump. The result of this is that sore shoulders are conspicuous by their absence and that the general condition of the stock is such as at once invites attention to the fact that working conditions are easy.

In addition to these advantages it is pointed out that the output capacity of the tractor-grader combination is greater than the output capacity of a plow and that in addition to its work in loosening material for the fresnos it can perform all the work of blading and finishing the cuts and fills. Just how much its capacity is greater than that of a plow team depends somewhat on weather and working conditions. It appears to be at least 50 per cent greater but possibly its advantage is greater than this. If fully utilized, it should then show a relative cost of operation no higher than the cost of plowing, which would leave all of the advantages of easier loading, better loads, faster travel time for the fresno stock, a more complete delivery of the loads taken on, and its utility in finishing cuts and fills as a net gain.

Another advantage not quite so apparent but nevertheless very real, is that in bringing a cut to grade with fresnos and a plow, it is difficult to take out the last layers of material with exactness. Cuts commonly are of different depths at the two sides and feather out at different rates at the two ends. As a result the most accurate results which can be obtained in taking out material by fresno or by wheeler require some correction, a heavy blade being the tool commonly used for this purpose. The tractor-blade combination has a considerable advantage here for it can take out the material just as accurately as it can finish the inaccurate work done by a plow and fresno or a plow and wheeler outfit—a saving time and labor which is of considerable importance.

Probably, adds Mr. Harrison, the tractor-blade outfit would work as well with a wheeler outfit as it works with a fresno outfit, though it might be a little more difficult to pick up a full load because of the different shape of the wheeler pan. However, the fact that the earth is really loosened by this method of taking it out, and placed on a smooth floor, should give much the same advantage—particularly in heavy material—which it obviously has in preparing materials for the fresnos.

Suggests Snow Removal Fund in Wisconsin.—E. F. Bean, Wisconsin State Highway Commissioner, in the course of a talk before the Wisconsin Road School at Madison, Wisc., said that snow removal in that state throughout the winter would cost $50 a mile, or $4,000,000 annually if all roads were cleared. This equals the yearly maintenance cost of the state's highway system. Lack of such funds prevents the work. He suggested that an additional one cent tax on gasoline during the winter months would keep clear 14,400 miles of road during the average winter.

West Virginia Needs $35,000,000 for Roads.—Approximately 35 million dollars will be needed to complete West Virginia's system of state highways, according to F. O. Sanders, head of the transportation division of the state road commission. The system now contains 3,780 miles of road, 1,800 miles of which are surfaced, 1,150 miles of which are graded, and 830 miles of unimproved. Eight million dollars would be needed each year to complete the system, he said, but no such money is in sight.

New Roads For Texas County.—Cameron County, Texas, will spend $2,500,000 this year on a program of constructing 18-ft. concrete feeder roads throughout the county. The entire program will cost $6,000,000, which has been provided by a bond issue passed at a recent election. These roads will lead from Brownsville to the farming communities in that region.

Puts Water in the Mix—Then Takes It Out

How Sioux City Pavements Contain Better Concrete Told by T. H. Johnson, City Engineer, at Convention of American Concrete Institute

The Abrams Theory, widely heralded as a method whereby concrete of a predetermined strength and uniformity could be placed at a low cost, has not been widely adopted. Since it places a premium on dry concrete, contractors have not always been willing to accept it in practice, for dry mixes are thought to be hard to place and to finish. Now comes the idea of putting enough water in the mix to afford any degree of plasticity, and then removing the excess water after workability is no longer needed. Sioux City, Iowa, has long used this method with apparent success. Mr. Johnson's statements before the American Concrete Institute are of real significance in the discussion that now interests every concretor.—The Editor.

Time, the new factor in concrete work, has enabled the contractor to better take advantage of the desirable properties inherent in cement, and therefore to make better roads. The same idea has its application to building work as well. This new idea was brought out quite forcibly by several speakers at the 23rd Annual Convention of the American Concrete Institute, which was held in Chicago on February 22 to 24. In fact, the development of that thought proved to be the highlight of the entire convention.

Before Mr. Johnson took the floor to tell how he had actually solved the problem on highway construction, the theoretical angles were discussed by P. H. Bates, of the United States Bureau of Standards and again by D. A. Abrams, director of the research laboratory of the Portland Cement Association, in a paper read for him by Mr. Gonnerman of that laboratory.

Tests Cited.—In these two papers the significance of the Abrams Theory, otherwise known as the Water-Cement Ratio Theory, was restated, and laboratory tests were cited that indicated that the optimum percentage of water required for the perfect hydration, or setting of cement could be exceeded at the mixer as long as the extra amount added for workability could be taken away from the concrete before the actual setting process begins. Thus, a mix whose water-cement ratio would normally give it but low strength can be actually turned into a high strength concrete by manipulation after the concrete has been placed inside the forms or on the subgrade. Tests cited by Mr. Bates showed that the use of an absorbent form withdrew this excess water and produced a concrete of good strength, simply because the removal of the excess water corrected the water-cement ratio to substantially the desired value.

Johnson Tells His Story.—These two papers awakened real interest, but it was not until Mr. Johnson, who is City Engineer in Sioux City, Iowa, told about his own work that those present began to realize the intensely practical applicability of the idea.

Mr. Johnson said that, by his method, the contractor could use any amount of water in the mix that he needed to reduce the labor of placing concrete in the slab. Then, by an especially prepared subgrade and by manipulation of the surface of the slab, he could remove the water in excess of that required for maximum strength according to the water-cement ratio theory, between the time the concrete is placed and the time when actual setting occurs. In this way he can get 5,000 lb. concrete at a total cost of less than $2.00 a square yard. This cost, he stated, includes 6 in. of grading, preparation of the subgrade, and the laying and curing of a 6 in. slab and expansion joint every 50 ft. No reinforcing steel is used.

Proven by Use.—Over 2,000,000 sq. yds. of such pavement, laid within the past decade, testify to the practicability of the method, he remarked. In spite of the low cost, in spite of the fact that the method is the direct opposite of usual paving practice, in spite of the lower cement factor, and in spite of the use of such a wet mix, it has been found that the contractor can safely guarantee such a pavement for 5 years and know that within that time the pavement will require no expense for maintenance. Mr. Johnson claimed that his work, even the first jobs, is remarkably free from cracks or checking.

How does he do it?

Dry, Loose Subgrade.—The first step in the process is to bring the subgrade to the desired level. Then, with a loose dry soil like loess, the subgrade is rolled lightly. With such soils as gumbo it is necessary to first harrow the soil to a depth of six or eight inches, and follow this operation by a light rolling. Holes, of course, are filled at this time, and the subgrade otherwise prepared for the concrete. In very damp soils, an absorbent top dressing of loose dry soil might be applied, taking it from the nearest possible borrow pit.

The concrete, usually 1:2½:4½, is next mixed so that it is delivered from the mixer at the consistency that would usually give a slump of about 6 in. It is shoveled onto the subgrade in the usual way, and is very easy to handle. The finishers then follow with a roller and belt, working the surface with all possible energy, and bring excess water to the top. At the same time the absorbent subgrade is pulling excess water out of the concrete to about half or two-thirds the thickness of the slab. During this part of the process most of the excess water is in this way withdrawn. So dry has the mix become that a man walking on the slab at this point, after but five minutes of finishing, will sink but a fraction of an inch in the mass.

Entrained air works out through the surface and escapes, allowing a perfect distribution of the course aggregate and eliminating all voids. Evaporation continues to dispose of the extra water that comes to the surface by capilarity. The constant rolling and belting anneals the slab into a uniform concrete of the required density.

Final Finishing.—Next, a mixture of half cement and half sand, in a dry state, is spread thinly and evenly over the surface. This draws more water from the slab and further aids in restoring the proper water-cement ratio. The process requires about 45 minutes. Bridges are thrown across the slab, and finishers with long handled floats and hand floats are put to work "massaging" this layer into the slab, keeping at it until the surface becomes too sticky to handle. The slab is then ready for curing.

Curing the Slab.—Mr. Johnson's curing method is to keep the slab sprinkled for five to seven days, depending upon the weather. This is to prevent too much moisture from being drawn from the slab, retaining the concrete at just the proper degree of dampness for hardening.

This treatment is such that the wet, almost sloppy concrete that leaves the paver is dried to such an extent during the first five minutes that a man can walk across the slab without sinking to the thickness of his shoesoles in the mass. In no other way could such wet and easily handled concrete be used and yet obtain a hard dense pavement.

How Others Do It.—With the usual method, the subgrade is supposed to be rendered firm and non-absorbent, and the finished slab is often covered with wet burlap to prevent the loss of any water. Ordinary practice calls for the use of tarpaper on a loess soil sub-

grade. Such methods have not always given success—while the methods described by Mr. Johnson are said to give satisfaction. In no case, he said, have any slabs popped up or cracked on loess soil or on any other soil.

Mr. Johnson has a theory of concrete work that realizes two steps in the building of a concrete road. First, there is the making of the concrete. That he classes as a science. Then there is the taking of this material and with it the making of the road. This second step he classifies as an art. Since the concrete that science calls the best is a mix that cannot well be used even by the skilled men of the gang in making the road, it is necessary to make a concession to practicability and add more water.

Workmanship Needed.—The men who take this wet concrete must then so manipulate it that it loses its excess water and becomes a sturdy slab that will bear the traffic and withstand the ravages of time. The art of making that road is then the art that requires such measures as are used by Mr. Johnson.

Just as the plasterer has done for generations, the paver takes a workable plastic material, applies it to an absorbent base, and then sand floats the surface to weld the material into a dense, strong and permanent mass, removing the excess water in the operation.

Granite Block Paving with Asphalt Filler

Construction Methods in New York City Described in Paper Presented Before the Asphalt Association

By C. M. PICKNEY
Chief Engineer Public Works, Borough of Manhattan, New York City

A span covering 19 centuries separates the narrow pavements of Pompeii, the oldest stone block pavements, still in existence, from the latest stone block pavements being laid in Manhattan.

The art of stone paving has changed from the use of large irregular slabs to a neat rectangular granite block, which, according to Manhattan specifications, must run between 6 to 10 in. long, 3½ to 4½ in. wide, and 4¾ to 5½ in. deep, and lay to an average ⅜-in. joint.

Joint Filler Used in Manhattan Borough.—In 1880 the bituminous joint filler was introduced, and since that time many experiments and a great deal of research has been undertaken to produce a joint filler which would not be materially affected by climatic conditions, which is stable, waterproof, noiseless and will wear level with the granite. In the Borough of Manhattan this question has resolved itself into the use of an asphalt filler having a penetration between 60 and 70 and a melting point between 115°F. to 130°F. The melting point is controlled in order that the filler may be heated on the street without elaborate heating apparatus, and the penetration is controlled so as to insure that it will flow readily into the joints.

In the Borough of Manhattan the joint filler used is a mixture of asphalt paving cement and hot dry sand in the proportions of 4 parts of sand to 6 parts of paving cement by volume. The use of this admixture was adopted after careful study, and it is the opinion of the writer that the addition of the sand increases the stability of the filler very materially, works great economy and adds to the filler a certain wearing quality which is most desirable. We find since the introduction of this sand into the asphalt cement that the filler does not run out of the joints on grades or into the gutters, where it is necessary to make a slightly higher crown than usual. The object of this joint filler is to keep the blocks upright, to preserve their arris, to reduce the noise which naturally comes from a hard pavement, and to waterproof the same.

We find in Manhattan, where the streets are continuously being opened to repair and install subsurface structures, that the asphalt joint filler adapts itself to this situation admirably in that the granite block filled with this asphalt joint filler can be easily opened, without destroying the granite, and can be restored and opened to traffic immediately.

Joint Filler Does Not Transmit Vibration.—In a city like New York, where the loads are exceedingly heavy and the speed of the vehicles is fast and where the surface of the streets are occupied to such a great extent by manhole heads, a great deal of vibration is set up. If the joint filler in a granite block pavement is such as to transmit this vibration to the curbs and, in turn, through the sidewalks to the adjoining buildings, a great deal of injury is done to the value of the building on account of vibration and it has been found that where asphalt filler has been used in the joints of granite block pavement, the vibration transmitted to the abutting buildings is negligible.

Inasmuch as the asphalt filler specified in Manhattan is obtained by the distillation of an asphaltic petroleum, it is essential that the methods of the refining be carefully examined into. The method of preparing the filler for application and the method of application should be carefully controlled.

Method of Applying Filler.—We find that the best results will be obtained if the asphalt is maintained in the kettles on the street at a temperature between 325°F. and 400°F., which is determined by equipping the kettles with thermometers. The sand, all of which must pass a 10-mesh sieve and not less than 85 per cent pass a 20-mesh sieve, is heated to a temperature between 300°F. and 400°F., the filler being poured into the joints between these limits.

When we began to use the admixture of sand and asphalt, it was the practice to mix the hot asphalt and sand in cans with a long spout and pour directly from these. Owing to the difference in specific gravity of the asphalt and sand, and the consequent rapid subsidence of the latter, this method was discontinued, and in 1917 the asphalt and sand were mixed in wheelbarrows, and the resultant asphalt grout flushed on to the surface of the pavement and broomed into the joints.

A few years ago the method of mixing was improved by the acquisition of mechanical mixers of the pug-mill type. With this mixer the asphalt and sand are placed in the mixer in the proper proportions and the asphalt grout is then emptied from the mixer into wheelbarrows dumped on the surface of the pavement and broomed into the joints. Thousands of granite blocks removed for the purpose of inspection show that invariably the asphalt joint filler has filled the joint from bottom to top.

It is the opinion of the writer that a well cut, closely laid granite block pavement, filled with asphalt joint filler, laid on streets where heavy traffic, high speed traffic, either horse drawn, motor driven steel tired or rubber tired, is eminently satisfactory, as the same is essentially noiseless, skid-proof, easily and satisfactorily repaired, and yet sufficiently smooth to compare favorably with other types of pavements, and is unquestionably the most durable type which has come to the writer's attention.

Scoria Surfacing Method

During the past two seasons the North Dakota Highway Department has constructed a few miles of scoria surfacing in the western part of the state which, from an economic standpoint is advantageous, due to the fact that there is no local gravel material available and it would be necessary to ship in this material at an excessive cost. Part of this has been constructed by using the "feather edge" section and part by using the trench section. As the scoria type of surfacing has a tendency to disintegrate, pulverize and shift under traffic, they found the trench section to be far more practicable than the feather edge for this kind of surfacing.

These interesting notes were related by J. E. O'Neil, construction engineer, of that department, in a recent issue of the North Dakota Highway Bulletin.

Maintaining Oregon's Highway Bridges

The Methods Used by the Oregon State Highway Department Described in Paper Presented at the Recent Annual Meeting of the American Association of State Highway Officials

By C. B. McCULLOUGH
Bridge Engineer, Oregon State Highway Department

A new problem is facing highway bridge engineers—that of an orderly system of periodic bridge maintenance. At first, the design of structures that would more adequately meet changing traffic conditions, and the construction of modern bridges on new routes absorbed the entire attention of state engineers. Maintenance of existing structures had to be left to the uncertainties of local activity.

With changing conditions came a broader conception of the responsibilities of a state highway department, and a greater centralization of activity and authority. The concept now is that of delivering highway transport—not merely roads.

With this change, bridge departments came to realize the need for considering the matter of maintenance in an orderly manner. Three distinct phases of activity were indicated from the beginning:

(a) A system of periodic inspections covering every structure in service on the line.

(b) The execution of repair and renewal work thus found necessary.

(c) A system of cost accounting sufficient in detail and exactitude to furnish a basis for estimating and budgeting future expenditures of like character.

Maintenance Inspections.—The systematic inspection of structures serves many purposes. As a safety measure, it is made at intervals frequent enough to insure time for emergency repairs in case any structural weakness is discovered. As a basis for a systematic service record, such inspections provide data for the selection of types of construction details for future work, and form a basis for estimating the probable service life of any structure. As a basis for budget making, data on the costs of needed repairs, renewals and betterments are afforded. The budgeting of all maintenance work except emergency repairs will permit doing the work when costs, labor supply, material supply and the weather are all most favorable, permits better management of the permanent forces, and otherwise leads to efficiency and economy.

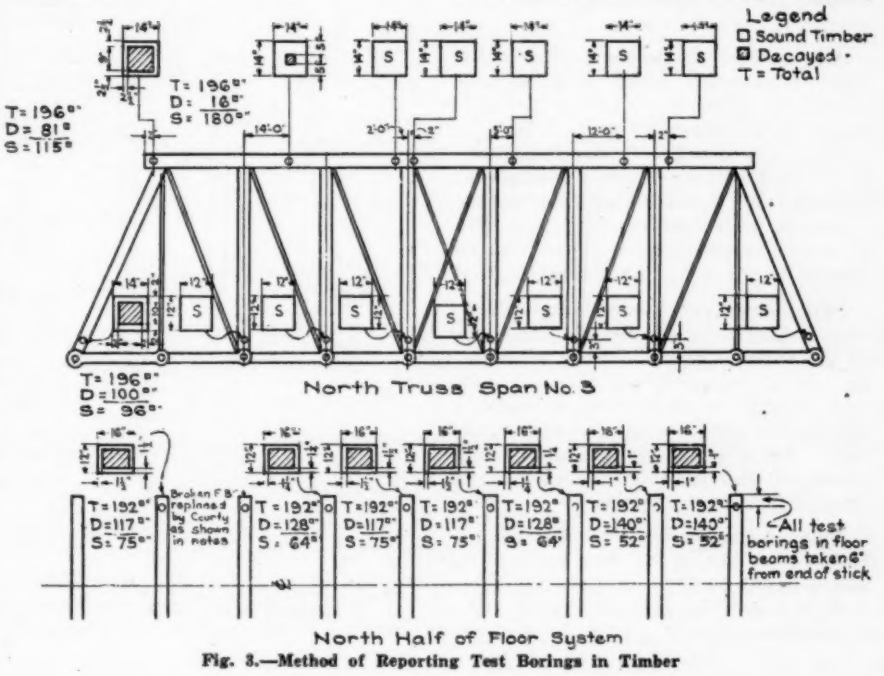

Legend
Sound Timber
Decayed
T = Total
North Truss Span No. 3
North Half of Floor System
All test borings in floor beams taken 6" from end of stick

Fig. 3.—Method of Reporting Test Borings in Timber

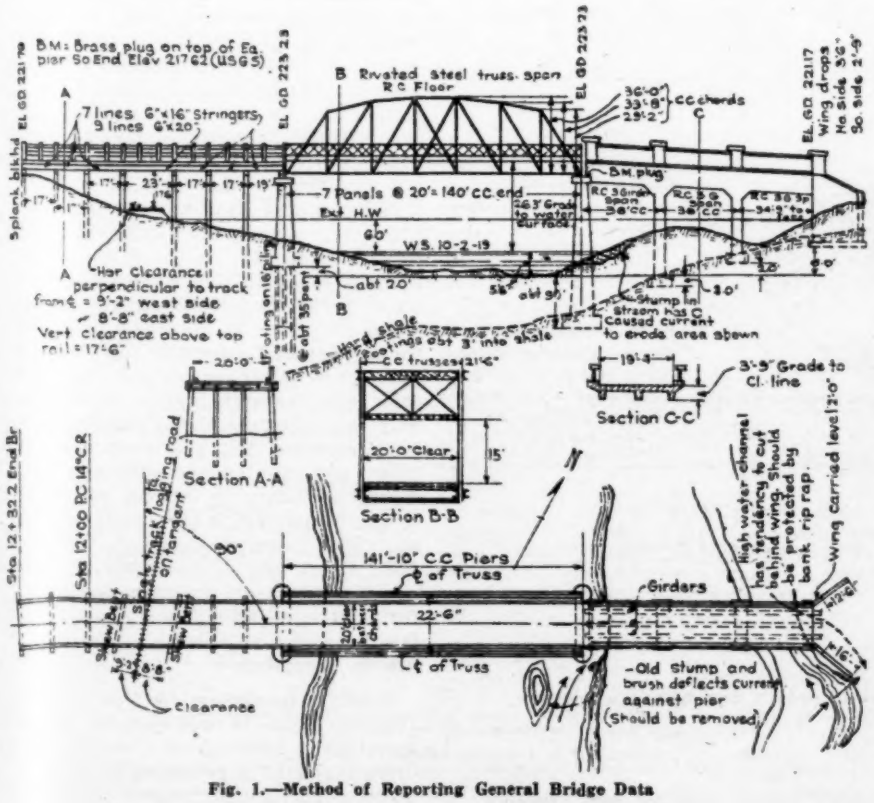


Fig. 1.—Method of Reporting General Bridge Data

The Oregon Bridge Department makes five distinct inspections, as follows:

1. The annual bridge inspection.
   (a) Primary annual inspection.
   (b) Subsequent annual inspection.
2. Supplemental inspections.
3. Bridge foreman's periodic inspection.
4. Periodic bridge inspection by patrol maintenance men.
5. Specialized inspections.

The Annual Inspection.—The annual inspection insures that every structure will receive a thorough and detailed examination by a party placed in the field for that purpose. At the primary inspection it will be necessary to take careful measurements and record detailed data that may be used in all subsequent work. When plans are already on record, this initial survey can be materially simplified, as much of the data will already be on hand. The data thus gathered is reported on special forms designed for that purpose.

All annual inspections thereafter may be reported which may be considerably abbreviated, since the detailed measurements are already a matter of record. Such inspections are only for the purpose of obtaining a record of the deterioration of the structure under service, together with data on any progression of defects observed at the previous inspection.

Supplementary Inspections.—Whenever a field engineer finds a structure in the vicinity of other work on which he may be engaged, it is usual that he will be able to afford time to make a supplementary inspection of that structure. Such inspections should be encouraged and may be reported on a special form or by letter.

Bridge Foreman's Periodic Inspection.—In addition to the inspections above noted, each foreman in charge of bridge maintenance work should make a complete inspection of each structure on which he works before leaving it. An inspection of this kind is very important. In many instances scaffolding is already swung in connection with repair work and a close-up inspection of details may be made with considerably less expense than would result otherwise. Moreover, tools and equipment are available at this time at no additional expense for hauling and the foreman generally has sufficient spare time in which to make this inspection without delaying the progress of his other work. Reports covering such inspections may be returned on blank forms prepared especially for this purpose, or by letter, as desired. In either case, the foreman should report not only the structural defects disclosed by his inspection, but also such items of repair and maintenance work as he considers necessary to correct the same. In this connection, it is essential that he segregate items of immediate necessity from items which may well be postponed until another season, the reason for this segregation being explained in the discussion pertaining to the bridge history hereinbelow.

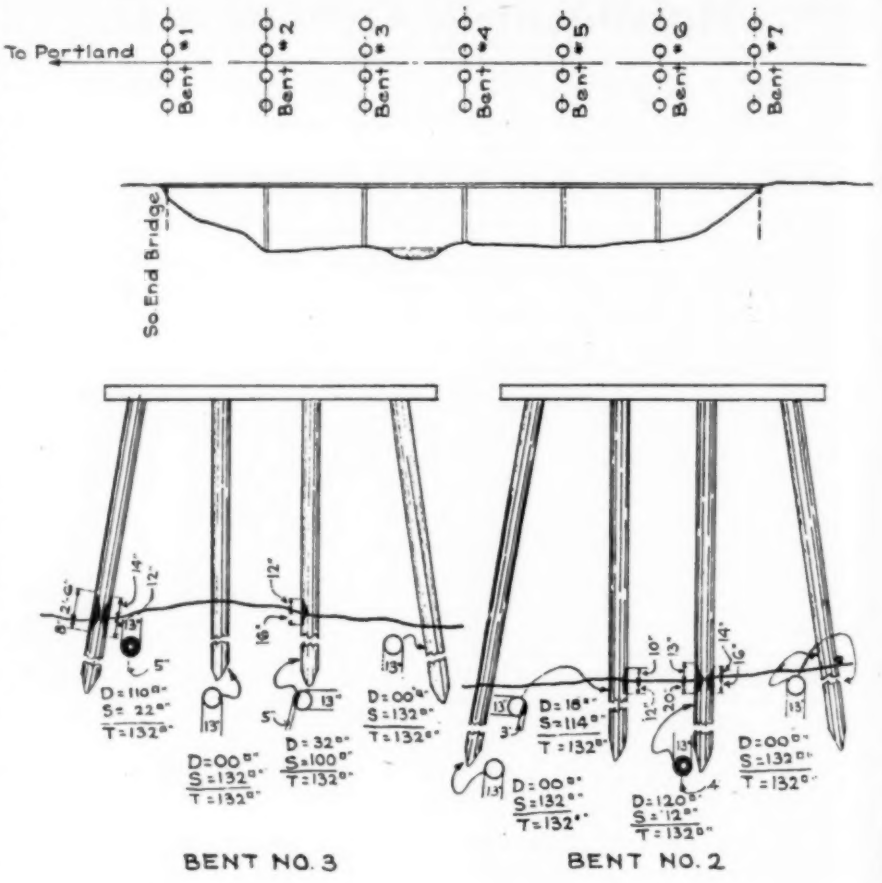


Fig. 4.—Typical Method of Reporting Decay in Timber

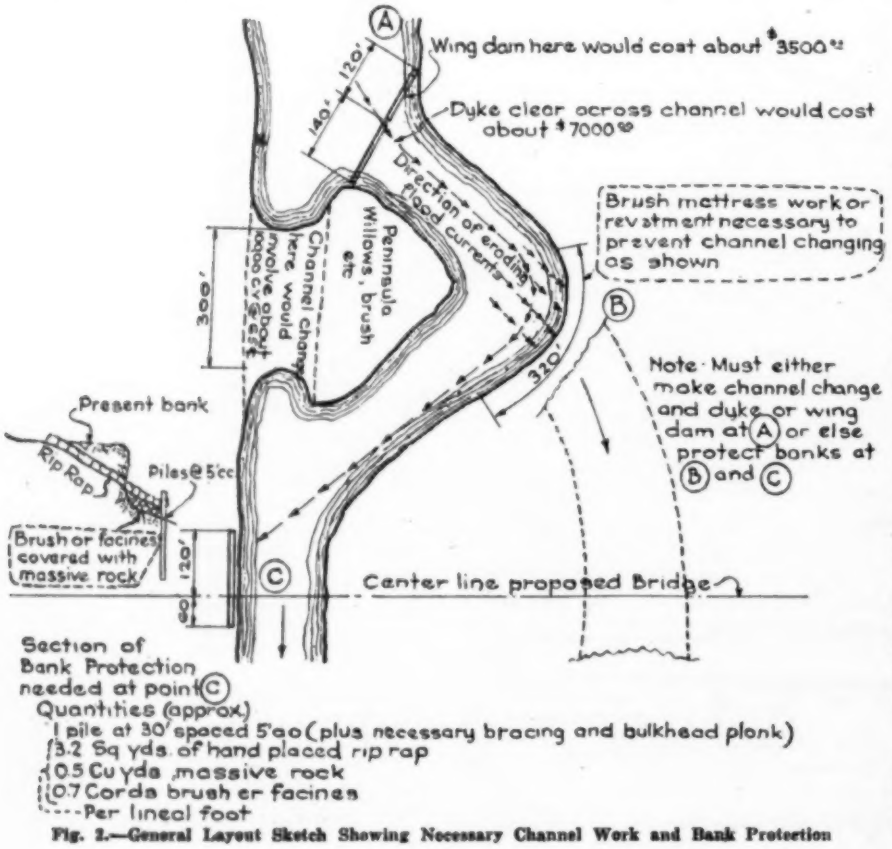

Wing dam here would cost about $3500.00
Dyke clear across channel would cost about $7000.00
Brush mattress work or revetment necessary to prevent channel changing as shown
Note: Must either make channel change and dyke or wing dam at A or else protect banks at B and C
Present bank
Rip Rap
Piles @ 5'cc
Brush or facines covered with massive rock
Center line proposed Bridge
Section of Bank Protection needed at point C
Quantities (approx.)
1 pile at 30' spaced 5'ao (plus necessary bracing and bulkhead plank)
3.2 Sq yds of hand placed rip rap
0.5 Cu yds massive rock
0.7 Cords brush or facines
---- Per lineal foot

Fig. 2.—General Layout Sketch Showing Necessary Channel Work and Bank Protection

Periodic Inspection by Patrol Maintenance Men.—In addition to the inspections hereinabove enumerated, bridges should be periodically inspected by local patrol maintenance men. The

OREGON STATE HIGHWAY COMMISSION

BRIDGE MAINTENANCE, REPAIRS AND RENEWALS.

Office Br No 762 Highway La Grande-Wallowa Lake County Wallowa
Location Br No. 10-432 Section 10 Township 1 North Range 42 E. Willamette Mer.
Stream Crossed North Fork Wallowa River
Nearest shipping point Wallowa Station Distance 1.25 miles
Description 1-109' Steel Pony Truss and 3-19' standard frame bents on concrete pedestals. (Steel tubular piers set 3' below stream bed on cemented gravel.)
Date built 1910 Built by Empire Construction Co. Cost of Construction $4830.00

REPAIRS RECOMMENDED				REPAIRS COMPLETED			
DATE		COST		DATE		COST	
Oct 12, 1922	Annual Inspection (J.F. Elgin & Party)			April 1, 1923 to April 18, 1923	(Work done by J.R. Jones and crew.)		
	1. New timber stringers throughout	700	00		1. Placed new stringers throughout	724	18
	2. New 6" timber deck & wheel guard	1000	00		2. Placed new 6" timber deck and wheel guard	963	47
	3. Spot point. steel floor system	25	00		3. Spot painted steel floor system	57	30
Jan 7, 1923	Supplementary Inspection (H.I. Griffith)				4. Enlarged slotted holes for greater expansion and contraction	16	40
	4. Enlarge slotted holes for greater expansion and contraction	15	00		5. Built rock walls to protect end shoes from dirt and grit.	40	80
	5. Build rock walls to protect end shoes from dirt and trash	35	00		6. Placed riprap around east tube	20	65
					7. Braced steel tube diaphragms	93	80
					8. Repaired broken handrail post	5	60
Feb 20 1923	Patrolmans Periodic Inspection Report (A.H. Larabee, Patrolman)				Total Cost	1922	20
	6 Rip Rap around east tubular pier	50	00				
April 7, 1923	Bridge Foreman's Inspection Report (J.R. Jones, Foreman)						
	Work of immediate necessity						
	7. Brace steel tube diaphragms	150	00				
	8. Repair broken handrail post	10	00				
	Total to here	1985	00				
April 7, 1923	Bridge Foreman's Inspection Report (Continued)						
	Work for 1924 budget (Approved C.B.M.)						
	9. Paint steel truss throughout	350	00				
	10. Place dripboard	75	00				
	11. Three additional lines of bridging	20	00				

Fig. 5.—Summary of Action Taken on Bridge Repairs

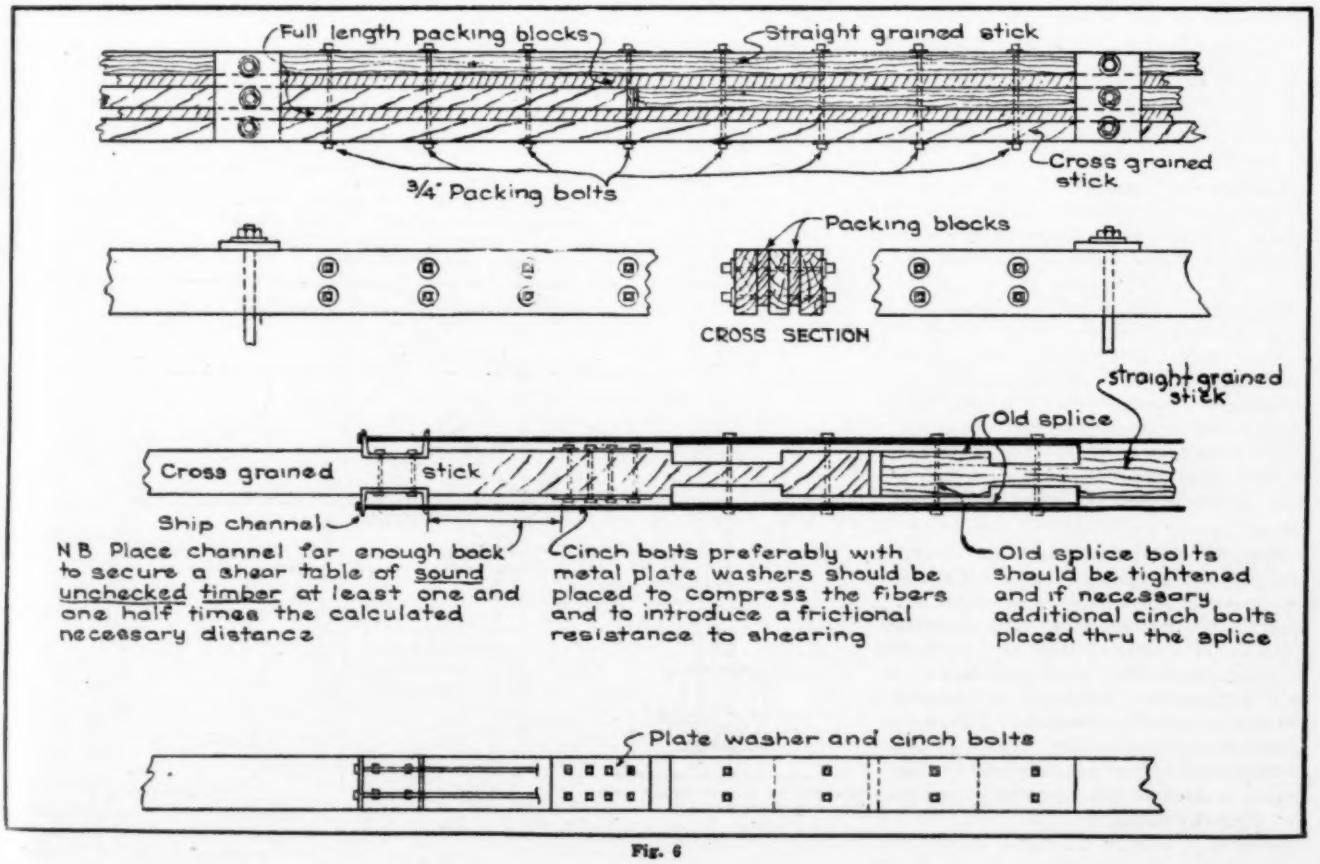

Full length packing blocks
Straight grained stick
Cross grained stick
3/4" Packing bolts
Packing blocks
CROSS SECTION
straight grained stick
Old splice
Cross grained
stick
Ship channel
NB Place channel far enough back to secure a shear table of sound unchecked timber at least one and one half times the calculated necessary distance
Cinch bolts preferably with metal plate washers should be placed to compress the fibers and to introduce a frictional resistance to shearing
Old splice bolts should be tightened and if necessary additional cinch bolts placed thru the splice
Plate washer and cinch bolts

Fig. 6

frequency of such periodic inspections depends upon the type of structure, its condition, character of traffic over the same, etc. Ordinarily a patrolman should examine all timber bridge structures on his line at intervals of not more than two weeks. In general, no special report need be returned by the patrolman unless his inspection discloses matters needing attention. However, one each quarter at least, either the patrolman or the resident engineer in charge of maintenance work on each section should return a report outlining briefly the condition of each structure on his residency.

Periodic inspections and reports of this character serve as a check on the other inspections and safeguard the system by placing the bridges under observation at much more frequent intervals than would be possible from the headquarters office. Reports of this character should call attention to all items of repair work of immediate necessity and to all conditions which have developed as the result of traffic accidents, fire, flood or progressive wear. Among such items may be mentioned the following:

1. Excessively worn floors.
2. Roughness or vibration of floors.
3. Damage to truss members, handrails, etc., from colliding truck.
4. Washouts, flood damage, erosion of foundations, etc.
5. Loose boards in timber floors.
6. Loose nails in timber floors.
7. Broken chord members, sheared splices, crushed bearings, etc., in timber work.
8. Caved shoulders or eroded slopes.
9. Badly decayed timbers, broken concrete handrails.
10. Any other items needing immediate or early attention.

Specialized Inspections.—In addition to the four inspections outlined hereinabove, it may be necessary from time to time to make specialized inspections covering one particular phase of the work, such, for example, as timber borings, rivet inspections, etc. Whether or not these inspections need to be made will depend upon the territory to be covered by each inspection party and the amount of work involved. It is oftimes necessary to place special parties in the field for such work as intensive timber inspection, rivet inspection, etc.

Sketches from the field always serve the purpose of amplifying and clarifying reports, but in the case of the annual inspection records, such sketches are doubly useful in that they furnish a permanent office record. Figures 3 and 4 illustrate the type of sketches needed in this connection. Figure 3 illustrates a method for reporting test borings in timber and Figure 4 illustrates a method for reporting on the condition of piling.

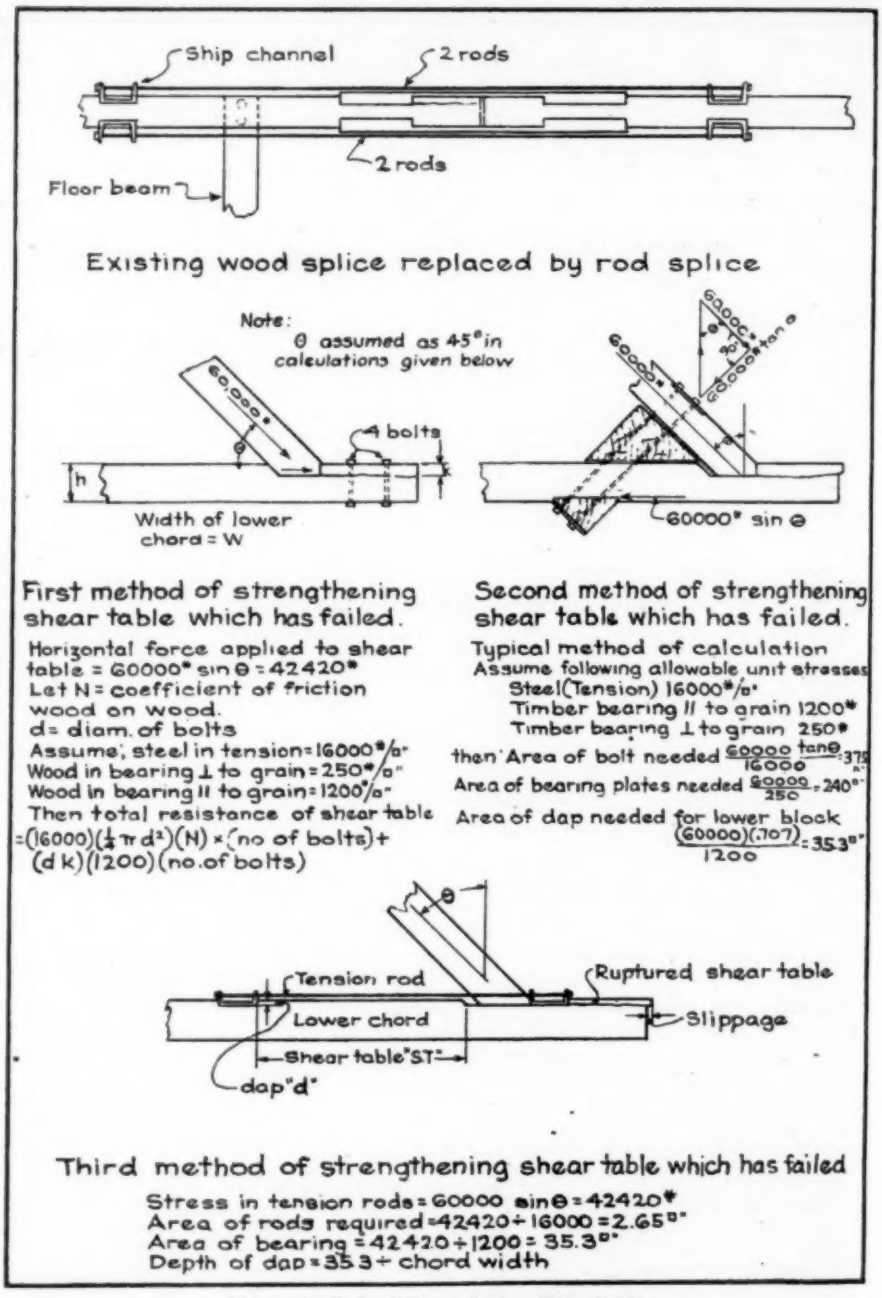
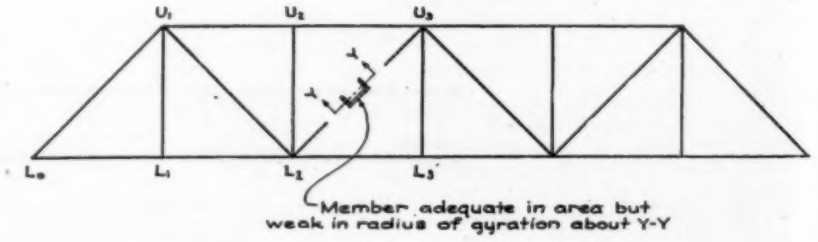

Ship channel
2 rods
2 rods
Floor beam
Existing wood splice replaced by rod splice
Note:
θ assumed as 45° in calculations given below
60000#
4 bolts
h
Width of lower chord = W
60000# sin θ
First method of strengthening shear table which has failed.
Horizontal force applied to shear table = 60000# sin θ = 42420#
Let N = coefficient of friction wood on wood.
d = diam. of bolts
Assume; steel in tension = 16000#/□"
Wood in bearing ⊥ to grain = 250#/□"
Wood in bearing ∥ to grain = 1200#/□"
Then total resistance of shear table
= (16000)(¼ π d²)(N) + (no of bolts) + (d k)(1200)(no. of bolts)
Second method of strengthening shear table which has failed.
Typical method of calculation
Assume following allowable unit stresses
Steel (Tension) 16000#/□"
Timber bearing ∥ to grain 1200#
Timber bearing ⊥ to grain 250#
then Area of bolt needed 60000/16000 tan θ = 3.75 □"
Area of bearing plates needed 60000/250 = 240 □"
Area of dap needed for lower block (60000)(.707)/1200 = 35.3 □"
θ
Tension rod
Ruptured shear table
Lower chord
Slippage
Shear table "ST"
dap "d"
Third method of strengthening shear table which has failed
Stress in tension rods = 60000 sin θ = 42420#
Area of rods required = 42420 ÷ 16000 = 2.65 □"
Area of bearing = 42420 ÷ 1200 = 35.3 □"
Depth of dap = 35.3 ÷ chord width

Fig. 7.—Methods of Strengthening Shear Table



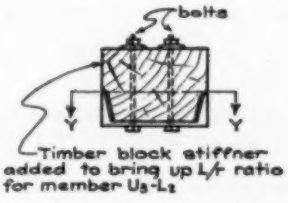


Fig. 10

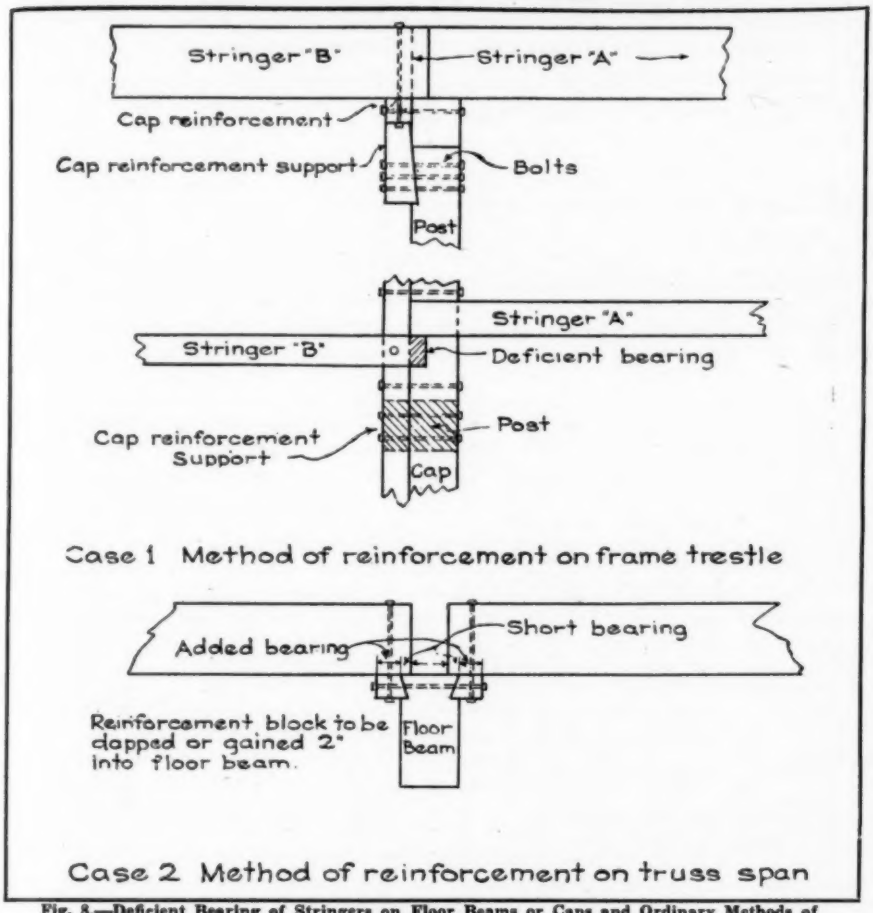


Fig. 8.—Deficient Bearing of Stringers on Floor Beams or Caps and Ordinary Methods of Reinforcement

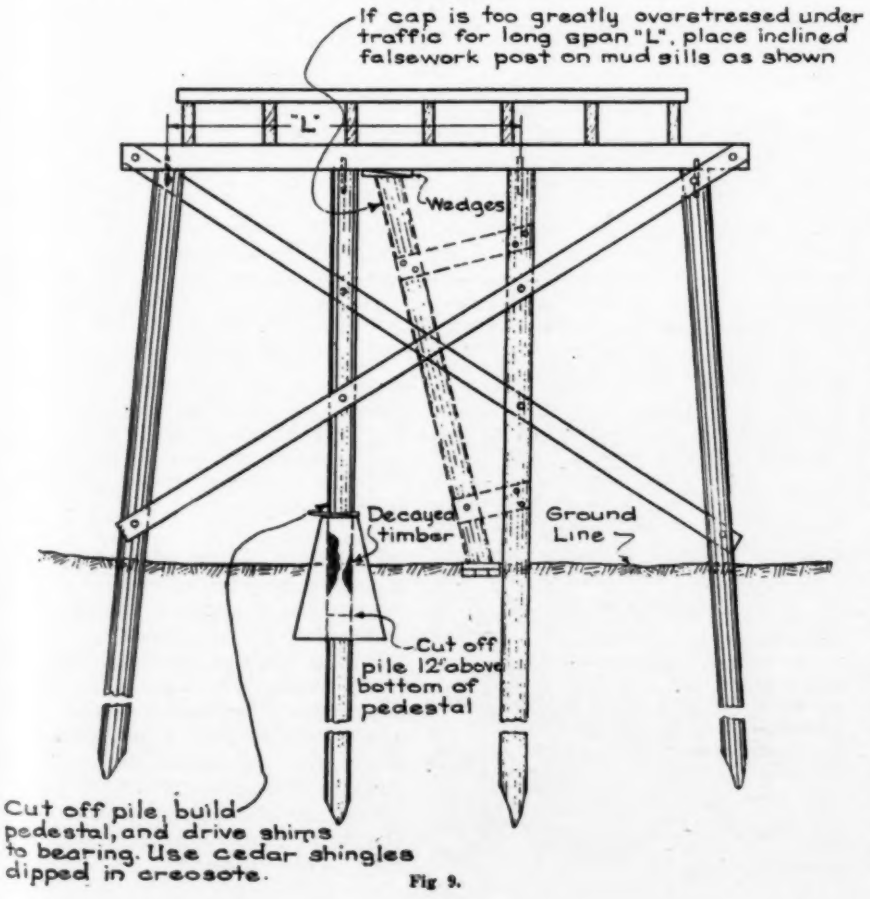

If cap is too greatly overstressed under traffic for long span "L", place inclined falsework post on mud sills as shown
"L"
Wedges
Decayed timber
Ground Line
Cut off pile 12" above bottom of pedestal
Cut off pile, build pedestal, and drive shims to bearing. Use cedar shingles dipped in creosote.

Fig 9.

The Bridge History.—The foregoing discussion has had to do with the various and sundry methods whereby highway bridge structures may be kept under constant observation. The various systems of inspection serve as a check one upon the other; one furnishing what the other lacks. It is apparent that as the result of each of these inspections, certain items of repair, renewal or replacement work will be recommended. Generally, repair items of this kind are returned on blank forms prepared especially for the purpose, but in any case it is apparent that during the year there will be numerous inspections and numerous recommendations. In order to coordinate the work of each of these inspection parties, and to keep an accurate record of all items recommended, the Oregon Department has adopted what is known as a "bridge history." This history or record book consists of a separate sheet for each structure on the line, ruled in ledger form, one side being a report of all repairs recommended and the other being a complete record of repairs made.

Figure 5 is a sample from the Oregon Bridge History, covering bridge 10-43.2. A glance at the record tells the following story: The structure was built in 1910. The first inspection was made October 12, 1922, by Elgin and party. Certain items of repair work were recommended as shown. On January 7, 1923, H. I. Griffith passed by the structure, made a supplementary inspection and recommended two other items of minor repair work apparently overlooked by the annual inspection party. On February 20, Patrolman Larabee reported the need for riprap around the east pier. All of these were posted in the bridge history sheet as they came in, were O. K.'d by the headquarters office and the necessary work order issued to Foreman Jones, who arrived on the job April 1. On April 7 Jones reported five items of repair work necessary, two of which were considered to be of immediate necessity, the others being budgeted for the succeeding year, a supplemental work order covering items 7 and 8 being then issued to Jones. The record on the opposite side of the ledger shows items 1 to 8 completed as per recommendations and items 9, 10 and 11 carried over for the following year.

A record of this kind serves as a general repository for all recommendations as they accumulate during the year. At the end of each fiscal year, they are gone over item by item, approved or disproved, as the case may be. The approved items are incorporated into an annual budget for the succeeding fiscal year. A record of this kind serves not only the purpose hereinabove set forth, but also furnishes an excellent service record for the structure and a record from which can be determined the detailed cost of maintenance for each structure on the line.

Bridge Maintenance.—The next phase of the problem has to do with the execution of such work as has been planned for the year. Space will not permit a detailed discussion of the many phases and ramifications of this problem. One particular feature, however, deserves mention at this time—that of maintaining in service some of the older and more or less obsolete structures which are present on nearly every highway system in the country. In general it may be said that highway bridge construction has not kept pace with the increase in improved road mileage, so that on practically every system in the country will be found numerous old structures, many of them in more or less advanced stages of decrepitude and decay, most of them obsolete as to traffic capacity, most of them seriously overstressed and resting on inadequately designed foundations. It is true that these structures are not up to standard and constitute an increasing source of maintenance expense, and a hazard to traffic. On the other hand, it is not the part of wisdom to adopt a policy of wholesale reconstruction, hastily discarding structures which may be kept in service over a period of years through a system of intensive maintenance. As a matter of fact, funds are not, as a general rule, available for a wholesale campaign of reconstruction. The bridge engineer is thus faced with the problem of programing his reconstruction a little at a time and in the meantime organizing for a system of intensive maintenance on such of the old structures as remain, carrying them under service with a minimum hazard to traffic and a minimum cost. This constitutes the real bridge maintenance problem and the one which has called for the greatest degree of skill and ingenuity.

The necessity for carrying such structures has made it necessary to work out schemes for reinforcement, some of them more or less makeshifts, others having more of a scientific foundation. Figures 7, 8 and 9, illustrate methods which have been worked out from time to time for the purpose of reinforcing and carrying such old structures in service. Doubtless most of these figures are self-explanatory. Methods of overcoming deficient bearing on caps and floor beams are indicated in Figure 8, while Figure 9 indicates a method which may be used for the reinforcement of decayed piling.

Field Cost Accounting.—Maintenance work is probably more difficult to estimate than any other type of engineering construction. If work is to be intelligently planned and budgeted, therefore. it becomes necessary to collect cost data covering at least the more common items of maintenance work. The greater portion of this data must, of necessity, be gathered in the field and Figure 11 indicates a form used by the Oregon Department for this purpose, the same being the bridge maintenance superintendent's final cost summary. In order that cost summaries of this character may be of value for the succeeding years, it is necessary to evolve a uniform and standard system of charge accounts. Such a system will doubtless vary with the individual needs of the organization.

STATE OF OREGON - STATE HIGHWAY COMMISSION

FINAL COST SUMMARY – BRIDGE MAINTENANCE

ORDER NO. 2MP-88-511 BRIDGE NO. 27-001

COUNTY Benton, HIGHWAY Alsea SHEET 1 OF 1 SHEETS

TYPE OF STRUCTURE 1-60' Housed Truss, 1-19'F.T. DATE April 1924 FOREMAN L.E. Torrence

CLASSIFICATION OF WORK			Wearing Surface Type - A		Cleaning & Painting timber H.R.		Hand placed riprap Grouted		Painting Housing		Misc. Items	
LABOR COSTS	Unit	Rate	No.	Amount	No.	Amount	No.	Amount	No.	Amount	No.	Amount
Payroll Mar. 16-31	M.H.	.54	56	30.38	65	35.18	133	71.88	55	29.45		7.35
Apr. 1-15	MH	.54	133	72.11	56	29.90	53	28.61	83	44.40		0.00
				102.49		65.08		100.49		73.85		7.35
MATERIAL COSTS												
Cement	Sk.	1.08½					12	12.30				
Sand	C.Y.	1.50					3	4.50				
Gravel	C.Y.	2.00	12	24.00								
Asphalt	Bbl	6.25	12	75.00								
White paint	Gal.	2.40			10	24.00			12	28.80		
Linseed oil	Gal.	1.25			2	2.50			3	3.75		
Carbolineum	Gal.	.80			20	16.00						
Freight	"	"		4.33		5.24				4.77		
Rip Rap Rock	C.Y.	.25		103.33		47.74	20	5.00		37.32		
EQUIPMENT COSTS												
Rental Truck #579	Da	3.00	7	21.00	2	6.00	3	9.00	2	6.00	2	6.00
Rental Ford Del #74	Da	1.00	6	6.00	5	5.00	5½	5.50	5	5.00	5	5.00
Operation Truck 579	Mi	.05	384	19.20		0.00	151	7.55		0.00		0.00
Rental Tar heater	Da	.50	9	4.50								
Misc.						1.00		7.20		18.50		
				50.70		12.00		29.25		29.50		11.00
SUPERVISION COSTS												
Sal & Exp.				8.91		8.91		8.91		8.91		
Car operation				4.71		4.71		4.71		4.71		
				13.62		13.62		13.62		13.62		
TOTAL COSTS				270.14		138.44		165.16		154.29		18.35
UNITS COMPLETED			540	sq. yds.	550	lin. Ft.	20	c.y.	15	gal.		"
COST PER UNIT				.50		.25		8.25		10.00		"

Total Cost this Bridge

Fig. 11.—Final Cost Summary

Annual Meeting of U. S. Good Roads Association.—The annual meeting of the United States Good Roads Association and the Bankhead National Highway Association will be held in Savannah, Ga., June 6 to 11. J. A. Rountree, 3200 Cliff Road, Birmingham, Ala., is director-general.

Road Construction in Russia.—The question of road construction in Soviet Russia is so important that several of the large trusts manufacturing building materials are considering forming a special company for the purpose of building and repairing gravel and surfaced roads. There is at present no organization of any size undertaking this work, with the result that it is being handled in a casual manner. It is proposed to form a company with the following concerns in control: The Cement Trust, the Ukrainian Silicate Trust, The Moscow Communal Economy, The People's Commissariat of Ways and Communications, and the Naphtha Syndicate. The basic capital, consisting of materials advanced on long term credit, is preliminarily fixed at 1,700,000 rubles.

Highway Maintenance Accounting

Methods Used by Michigan State Highway Department Described in Paper Presented Feb. 17 at 13th Annual Conference on Highway Engineering at University of Michigan

By B. C. TINEY

Maintenance Engineer, Michigan State Highway Department

An efficient accounting force is a very necessary part of a maintenance organization. Discontent and friction in an otherwise excellent field organization are bound to result from any unreasonable delay in auditing and paying of payrolls. Prompt payment of freight and material bills promotes satisfactory relations with railroad and material companies, and consequently better service from them. In addition to smoothing out and promoting progress of the work in the field, a good office force has up-to-date records of the past work on file, enabling the superintendent to know how much money has been spent from the budget set up for each section of work. Continuous knowledge of the unit costs of work, while it is in progress, is very valuable, as it often points to the necessity of changes in methods, equipment or personnel.

The keeping of public accounts is frequently regarded as a red-tape process, involving many unnecessary operations, but it should be kept in mind that certain safeguards must be thrown around the disbursement of public money, for the protection of both the public and the official in charge.

The engineer or superintendent in charge of highway maintenance work has a great variety of duties to engage his attention. His field forces are working under the direct observation of the driving public, and any lack or delay in proper performance is reflected in the condition of the roads. There is, therefore, a very natural tendency for him to concentrate on the outside problems and to fail to organize his office work on the same efficient basis as field work. Much improvement might be made, throughout the state, in this respect.

It has been the aim of our maintenance division to reduce the keeping of accounts to the most simple process consistent with recording the desired information.

Combination of Sections.—With the beginning of the trunk line maintenance work under the Aldrich Act in 1919, the trunk line roads were divided into maintenance sections and each section set up in the accounts as an individual project. Sections were usually confined to one type of road and often to individual construction projects. On gravel roads, sections were arranged in length to correspond with the daily round of a horse-drawn patrol. Construction of different types of surface brought about annual changes in the arrangement of these sections. The growing use of motorized patrols on gravel roads increased the mileage covered daily by each patrol unit and resulted in longer and fewer maintenance sections. In 1925 our books still carried about 1,200 sections, many of them comparatively short, and while this arrangement was desirable in that it furnished the maintenance history of different construction jobs, the department felt that it involved more clerical work than was warranted by the results. Further combinations of sections were made, reducing the total number in 1926 to about 500.

It is possible that we may have gone too far with these combinations and simplified the bookkeeping, in some cases, at the expense of sacrificing some desirable maintenance cost data. This is particularly true where very old pavement jobs have been combined in the same sections with new pavements. The present arrangement, however, is very satisfactory from a business standpoint.

Payment of Payrolls.—The trunk line maintenance work is at present conducted in 59 counties by contracts with the county road commissions and in the remaining 24 counties by state force-account organizations.

Payrolls in contract counties are paid semi-monthly by the county road commissions and summarized in monthly statements to the state highway department. In state organization counties, payrolls are made up semi-monthly in the offices of the maintenance supervisors, from daily reports received from the superintendents. These payrolls are sent to Lansing where checks are written by the auditor general. We have had very few complaints regarding the length of time required to get checks back to the men on the work, and believe this system preferable to that of establishing local checking accounts for superintendents.

Purchase of Maintenance Material.—All major maintenance materials are bought by the state purchasing department on requisitions from the maintenance division. Invoices are sent direct to the state administrative board. Freight bills and information relative to the quantity and condition of materials received on the work are furnished by the county superintendents to our maintenance supervisors, who then make up delivery reports and forward them to Lansing as supporting evidence for the payment of invoices. This system was first used during 1926 and has been fairly successful in handling the payment of invoices within the periods specified by materials companies for taking of cash discounts. A 10-day period from date of invoice is a rather short time to secure delivery reports from distant parts of the state and companies will be asked, this year, to extend this time to at least fifteen days. The chief cause of delay has been the securing of freight bills, which must be filed with delivery reports before the administrative board will pay the invoices on materials. It frequently happens that materials are bought at a certain price, delivered, but through an error, the company ships them freight collect. In these cases the State pays the freight and deducts it from the invoice. Freight bills also furnish the official railroad weights of commodities shipped, and for such materials as sand, gravel, and crushed stone, they provide the state's only definite information as to exact quantities received. For these reasons, it is important that the freight bill accompany the delivery report, even though the freight is prepaid.

It is often difficult to obtain more than an approximate estimate of the quantities received, as in the case of the number of gallons of bituminous material in a tank car. Actual check of quantities is made whenever possible. A record of the date of arrival and time of unloading should be kept for cases of demurrage and car rental.

Rental of Equipment.—In contract counties, equipment is furnished and kept in repair by the county road commissions, and a daily rental is paid by the state for its use. Rental tables were developed by the department for this purpose, in 1919, and changes have been made in these rates from time to time, revising the rates upward as conditions seemed to warrant. It has been contended by some counties that they were losing money on these rentals while others considered the rates equitable. Particular claims were made on snow removal equipment and mowing machines, as being subject to extreme breakage.

The elements involved in determining daily rental rates are: Original cost, economic life of equipment in years, average number of days used per year, depreciation, interest on investment and annual cost of repairs.

Owing to the shorter summer season in the northern part of the state the summer equipment does not give quite as much annual rental return to northern counties as it does to southern counties. The extension of snow re-

moval work toward the north, however, has tended to equalize this matter by giving the northern counties a longer period of use for winter equipment. The department feels that our present rates are fully high enough to justify the making of an investment in equipment—for example, a $6,500 tractor draws a rental, per 10-hour day, of $30.16; a $4,000 truck, $13.48; a $3,000 rotary snow plow, $27.84. Equipment should be traded in, or junked, at the end of its economic life. We believe that many of the complaints of losses which have been received from counties, have been the result of using equipment so many years that repairs became excessive.

Overhead Charges.—Overhead charges, covering the salaries and expenses of county maintenance superintendents and office forces, are paid quarterly to contract counties, on a sliding scale of percentages which varies with the cost of the year's work. For example—an annual expenditure of $47,000 or more carries an overhead of 5½ per cent while an annual expenditure of $20,000 or less draws an overhead of 9 per cent. The scattered location of maintenance work justifies a higher percentage for supervision than on a construction job where activities are more concentrated. The adoption of a percentage plan in paying overhead to contract counties was thought advisable because of the varying salaries paid by counties to their superintendents and in turn charged to the state.

Reports.—Superintendents in state organization counties are not provided with offices, but their clerical work is reduced to an absolute minimum. They are required to make only one report, which is a daily report to the maintenance supervisors showing the labor payroll, equipment rental time, and sundry purchases of supplies. These daily reports are compiled by a clerk in the maintenance supervisor's office and summarized twice a month. Equipment rentals are charged against the budget of each maintenance section on which the equipment was used and are credited to the maintenance equipment fund. The same rates are used as with contract counties. Repairs to equipment are charged against this fund.

In one section of the state there has just been introduced, in state organization counties, a daily report from each truck or tractor driver to the county superintendent, showing hours worked, miles traveled, gas and oil used and time out for repairs. This is being tried for the purpose of determining the efficiency of different drivers and different kinds of equipment; also as a means of putting each driver on his mettle.

An automatic recording device is used on all trucks operated by the superintendent who is in charge of the combined trunk line maintenance work in Luce and Mackinac Counties. This records on a circular chart the history of the operation of the truck for each day. If the truck stops on the work the chart shows the time of day and the length of time it was not operating. These charts are sent by the driver to the superintendent, daily, and furnish an excellent means of checking on equipment which is working at a considerable distance from headquarters. They are used as a basis of payment for a number of hired trucks.

The hiring of trucks with the owner furnishing the truck, driver, gas, oil and repairs, at a stipulated rate per hour for the actual time worked, has some advantages over owning trucks. It eliminates the original investment as well as all accounts of gas, oil and repairs and reduces the proposition to a payroll. This system first came to our attention several years ago in Kalamazoo County, where the County Road Commission considered it more economical and just as satisfactory as owning trucks. The state has since used it in a number of direct organization counties with good results.

Classification of Costs.—During the past few years, efforts have been made to standardize maintenance accounts in the different states comprising the Mississippi Valley Association of State Highway Departments, in order that comparisons might be made of maintenance costs in these states. The classification of costs in use at present by the Michigan State Highway Department conform substantially to the recommendations of the committee on this work, except that it further subdivides some of the classes.

Our classification, with some comments on the nature of these charges, is as follows:

1. Roadbed—Filling ruts and washouts on shoulders, cutting weeds and cleaning out ditches.
2. Structures—The repair of culverts and guard rail and the erection and removal of snow fence.
3. Dragging—The patrol floating of roads as well as scarifying and reshaping with heavy graders.
4. Patching—Replacement of limited areas of road surfaces.
5. Dust Layers—The application of dust paliatives, such as calcium chloride and light asphaltic oil, to afford a temporary reduction of dust without matting the surface.
6. Resurfacing — Surface renewals over extensive areas, usually embracing full width of the metal. This includes bituminous surface treatments of macadam and gravel roads, with the exception of the first treatment which is classed as a betterment.
7. Snow Removal—The removal of snow and ice and the sanding of slippery road surfaces.
8. Traffic Census and Truck Weighing—Counting and restricting traffic.
9. Markers and Signs—Painting and repairing of signs and replacing broken signs.
10. Roadside Development — Trimming trees and planting trees and shrubs.
11. Betterments—Increasing width of roadbed and improving drainage, grades, alignment and vision.

Increasing the width or depth of wearing surface over original maximum widths or depths. This includes initial bituminous surface treatments.

Building new drainage structures, retaining walls, and guard rails. This covers the replacement of existing drainage structures with those larger or of improved type.

In addition to these eleven divisions we carry the separate item of overhead.

The calendar year, rather than the fiscal year, is the period used for tabulating maintenance costs as it represents a continuous summers' work and breaks at a time when maintenance activities are usually the lightest. The cost records are used, annually, in computing the average cost per mile for maintenance of the various types of road. Inasmuch as the cost per mile is of little comparative value unless the traffic is also considered, the traffic count is used with the cost records in developing the cost per vehicle mile on different types.

Traffic Counts.—Prior to this year, all traffic counts have been taken in the summer and fall seasons, and the average daily traffic at each station has been multiplied by 200 to obtain the total yearly traffic. This factor of 200 was probably nearly correct before the extensive development of snow removal work but winter traffic is increasing rapidly and with a view to obtaining more accurate information on the total annual traffic and on the distribution of traffic throughout the year the department is planning, this year, to take a Sunday and a week-day count in each quarter, or a total of eight counts which will figure in the development of vehicle-mile costs.

In comparing the maintenance cost per vehicle mile of the same type of road in different states, or in different parts of the same state, a number of factors other than the actual costs are to be considered. The width, thickness, drainage and age of the different sections vary greatly, with a corresponding effect on maintenance costs. A few poorly designed or poorly constructed sections of a certain type of road surface may raise the average maintenance cost to such extent that it compares unfavorably with that of the same type in other states, or of other types in the same location.

The quality of the maintenance work and the character of the service given to the public should be considered in comparing costs. We might find practically the same cost per vehicle mile for maintaining gravel roads in two different states or counties, with one giving a 100 per cent service and the other, by the same standard, 50 per cent.

Traffic Control by Electric Signal Lights

Experiences at Washington, D. C., outlined in Paper Presented January 20 at Annual Meeting of American Society of Civil Engineers

By M. O. ELDRIDGE, Assoc., M. Am. Soc. C. E.
Director of Traffic for the District of Columbia, Washington, D. C.

If costly congestion is to be relieved the flow of traffic must be rapid. Rapid flow of traffic is extremely hazardous unless it can be smoothly operated with absolute safety at intersecting streets.

Synchronized, Progressive and Co-ordinated Systems Compared. — Synchronized traffic signals whereby all lights on a main artery of travel showed "green" for a given period, then "red," were originally thought to produce the best results. Modern practice, however, has a tendency to abandon this form of control in favor of the progressive or co-ordinated system whereby a vehicle traveling on a main street gets a change of signal at each cross street and is then able to proceed the full length of the controlled section at a predetermined rate of speed without a stop.

Under the old synchronized system the timing on the main street was necessarily long in order that traffic might move as far as possible before a change of signals brought it to a halt. In congested business districts this tended to cause traffic jams in the cross streets because vehicles were necessarily piled up in these streets for from one and one-half to two and one-half minutes on each signal change with the result that each cross street became completely filled and when the green light appeared there were too many vehicles in the block to clear the intersection before the red light came on again. In fact it was not unusual for two or three changes of signals to be required to clear a given vehicle from a cross town block.

The progressive and co-ordinated systems are operated on a much shorter timing, 30 to 45 seconds usually being sufficient. This results in fewer vehicles being caught in a block when the red light shows and leaves space for parked vehicles to pull out or for others to get to the curb. It also permits a smaller number of vehicles to clear the intersection on one signal change.

With the synchronized system no speed control was possible except by motorcycle police, while with the more modern type mentioned the timing can be set to permit any desired speed.

In Washington a driver can run 12,000 ft. on 16th St. where the traffic is comparable to 5th Ave., New York, in 7 minutes at approximately 20 miles per hour. This speed can be varied by the very simple expedient of changing the timing so that either a faster or slower speed will be necessary. It is obvious that in order to get through the controlled section the speed must be maintained in conformity with the timing of the signals, otherwise the driver will be stopped at each intersection.

How Synchronized System Is Changed to Progressive System.—For those cities already equipped with synchronized systems it might be of interest to note that such systems are easily changed over to the progressive type of operation at no other expense than a few hours' labor. This can best be done at night when traffic is lightest and is accomplished by the simple means of reversing red and green lenses on alternate signals or on alternate groups of signals so as to obtain a run of a length to produce the desired average speed.

In Washington where the length of the blocks varies from 250 to 1,000 ft. it was necessary to group the lights singly or in groups of two or in groups of three intersections, depending upon the length of the blocks.

A traffic officer is needed to control the intersection at which the change is being made only while the work of changing the lenses is under way and this officer can accompany the gang from street to street until the whole is completed. After the change is effected the lights should be carefully watched and the controlled section should be frequently run by an official car for a few days until the proper timing and any additional signal lens changes have been determined. When all is operating in a satisfactory manner the wire terminals in the signals should be reversed where lenses have been changed and the lenses should be replaced so that the colors on all signals will be in the same relative positions as an aid to color blind drivers.

Co-Ordinated Signal More Flexible.—Co-ordinated signals are more flexible than those installed for progressive operation but it is doubtful if this additional flexibility warrants the added expense. Co-ordinated control permits a variation in timing at each separate intersection and is undoubtedly ideal if expense is no object. Co-ordinated control apparatus is, however, expensive and delicate and the variation desired at the different intersections is usually so slight that the additional cost of apparatus and cable is generally unwarranted. This extra cost for cable is apt to be considerable as it is necessary to run separate cables from each intersection to the control apparatus.

There is much difference of opinion as regards the use of an amber light in addition to the red and green lights. Our experience in Washington has, so far, led to the conclusion that the use of an amber light is necessary in order that a maximum of safety may be afforded to the pedestrian and the intersection cleared of moving traffic. It is apparent, however, that the use of the amber light is a subject that merits the careful consideration of all traffic engineers.

The Use of the Amber Light.—The amber signal is not a STOP signal; neither is it a GO signal. Its purpose is to warn moving traffic that the GO period is almost over and a STOP signal will be flashed in 5 seconds. Drivers who are within 50 or 60 ft. of an intersection have ample time to continue crossing the intersection and be out of the way before the direction of the traffic changes, while drivers who are further back from the cross walk have plenty of time to bring their cars to a gradual stop without suddenly jamming on their brakes, and possibly causing the following vehicle to collide with them.

On the other hand, the use of the amber light after the red is not justified because standing traffic has no need of a warning that the signal is about to change. Experience has shown that where this warning is given by flashing the amber light after a red light, standing traffic is apt to anticipate the green light and start too soon, thus endangering the vehicles that have not at that time finished clearing the intersection.

The Ideal Traffic Cycle.—The ideal traffic cycle might possibly consist of a green light displayed for a predetermined number of seconds, followed by an amber light displayed for 5 seconds, followed by a red light displayed for the desired length of time, followed by a green light. Such a cycle would afford ample protection to the pedestrians who might be walking with the signals, as it would provide time for those walking with a green light to reach a point of safety, while the red signal on the intersecting street continued to hold traffic.

Right and Left Turns.—There seems to be little uniformity in the method of taking right and left hand turns in the different cities. Right hand turns are always dangerous, because vehicles are obliged to pass over two cross walks and necessarily cut through the line of pedestrians walking with the proper signal.

In Washington all right turns are made when confronted by a green light, in order that the turning vehicles will not encounter a line of moving traffic.

Left turns are less dangerous, because they can be controlled and the vehicle only passes over one cross walk at a time when no pedestrian has a right to be there. They should, however, be eliminated whenever possible at intersections where two-way traffic is permitted on both streets, as under this condition they tend to cause congestion.

The driver desiring to make a left turn in Washington pulls into the intersecting street when the light confronting him is green, keeping as far to the right as possible. He then stops alongside the cross walk in such a manner as to block traffic on the intersecting street, leaving ample space for through traffic to pass on his left. When the signal changes the turn is completed This method of making the left turn on streets controlled by traffic lights has proven to be eminently satisfactory.

At points where a two-way street intersects a one-way street, the driver wishing to make a left hand turn stops at the right hand curb, just back of the cross walk line, and when the signal changes to red, stopping through traffic on the two-way street, the turn is completed. eVhicles moving on the one-way street make the left turn into the two-way street when running on a green signal.

The Washington Signal System.—The signal system in Washington is divided into different zones, and the controlling apparatus in each zone is installed in a conveniently located fire engine house. At each of these controlling points an operator is continually on watch whose duty it is to operate the fire signal, and in case of emergency to throw the switch changing the control from automatic to manual, and to then operate the signal by the manual control while the emergency exists.

The Washington fire signal consists of an amber and red light displayed simultaneously in all directions. This is a flashing signal operated at approximately 30 flashes per minute, and all traffic is required to clear the intersection and come to a standstill, while the signal is on. The length of time that this signal is displayed depends entirely upon what fire apparatus is using the streets, and varies from 45 seconds to 3 minutes. The operators are furnished with a list of fire alarm boxes, which call for a display of the signal together with the length of time that the signal should be operated for each box. The chief of the fire department reports that the use of this signal has been of great benefit to the movement of fire apparatus.

Electric traffic signals have come to stay. Their usefulness and efficiency have been clearly demonstrated, and there is no question whatever but that they are a vital factor in the reduction of traffic accidents.

Field Motor Truck Impact Tests Now in Progress

A special series of field motor-truck impact tests, now being carried on by the Bureau of Public Roads, is expected to be completed within a few months. The objectives of these tests were determined from a study of the data secured during the original program which has been completed and reported on. The work is in cooperation with the Society of Automotive Engineers and the Rubber Association of America.

Impact Reactions Dependent on Four Variables.—Based upon the findings of the original program, it is believed that motor-truck impact reactions are dependent on four major variables, namely, road roughness, tire equipment, wheel load, and vehicle speed. It is not believed that the effect of one variable should be considered without due regard for the other three. From the original program it was possible to plot lines of equal impact reaction for one road condition, four tire types, and various combinations of load and speed. The result was a series of isodynamic curves from which could be read the maximum total vertical reactions in thousands of pounds that might be reasonably expected to occur on that particular road for any combination of wheel load and truck speed. The data were segregated by tire types such as pneumatic, new cushion, new solid, and worn-out solid equipment; and the curves represented a range of wheel loads up to 20,000 lb. and speeds from 0 to 30 miles an hour. The tests were made on the Arlington test road which had been roughened by artificial obstructions.

With this preliminary isogram as a basis, a program of tests was formulated, the field work of which is expected to be completed within a few months. A number of highway sections have been selected as representative in type and roughness. These sections were marked off in one-twentieth mile lengths and points were spotted on the pavement with traffic white to guide the trucks over the test sections. The road sections were calibrated carefully at varying speeds by means of the "roughometer." The roughness limits ranged from 100 to 800 units at a speed of 30 miles per hour.

Tire Equipment for Tests.—Tire equipment was selected to represent the four types used in the preliminary investigation, namely, pneumatic, new cushion, new solid, and worn-out solid. The average deflections of the four types under a static load of 10,000 lb. were approximately 2.5 in., 1 in., 0.7 in., and 0.2 in., respectively. The tires were mounted permanently on extra wheels in order that tire changes might be made rapidly and conveniently by substituting wheels.

At the beginning of the tests the rear-wheel loads were standardized at 2,500, 5,000, 7,500, and 10,000 lb. Two trucks were used, a 2-ton truck for the 2,500 and 5,000 lb. loads and a 5-ton truck for the other loads. The light load of each truck was accurately measured on platform scales and securely fastened in position. Then the heavier load was built up on each truck by adding 100 lb. lead or iron weights. The positions of these extra weights were marked on the trucks so that the wheel loads might be duplicated readily.

The trucks were operated at speeds varying by small increments from the minimum up to the maximum speed obtainable. The average speed of each run was computed from stop-watch observations and the known length of the test section. Variations in speed were observed from speedometers mounted on the trucks. Runs varying from the average speed by more than one-half mile per hour as registered by the speedometer were not recorded.

Organization and Equipment.—A field-test program of this character made necessary a mobile organization and equipment. To provide for this a field office and two loading and storage platforms were built on a 16-ft., 3-ton trailer chassis. On a 2-ton truck chassis a special platform body was constructed with a swinging chain hoist placed at the forward end. In addition to hauling the trailer this service truck was used to carry the spare wheels, gasoline, and general equipment necessary for the tests.

The 2-ton and 5-ton test trucks were equipped with the coil-spring accelerometers developed by the bureau, which were mounted so as to follow the vertical motion of the right rear wheels.

Municipal authorities in the District of Columbia and in Alexandria, Va., were interested cooperators in the tests made within their jurisdiction. Traffic officers were assigned to assist in the work, and they were extremely valuable in making it possible to conduct the tests on the streets with safety.

The value sought in these tests for each combination of the four variables was the average of the five highest impacts occuring within the 1/20 mile section. This represents the magnitude of the average impact which occurs at the rate of 100 per mile. Since the unsprung component of motor-truck impact is generally the important quantity, it was considered sufficient to compute this unsprung component and add to it the sprung component determined by static weighing in order to arrive at the total impact force. An attempt will also be made to express the absolute maximum in terms of the average of five highest impacts. The indications at present are that useful and reasonably accurate results may be obtained.

Fill Settlement in Peat Marshes

Studies of Michigan State Highway Department Described in Paper Presented at 5th Annual Meeting of Highway Research Council

By V. R. BURTON

Engineer on Special Assignments, Michigan State Highway Department

The Michigan State Highway Department has just completed a special study of fill settlement in peat marshes as a part of the general soil survey it has undertaken. Settlement in peat marshes has caused serious trouble in many places, because it was unknown how much fill material would be required and even after the fill had been completed there was no assurance that it would maintain the original grade line. It was therefore desired to ascertain the physical characteristics of the peat and decide on the field data necessary to properly locate and estimate the cost of a road over a peat deposit. It was hoped that it would be possible to devise a method of construction more economical than that then in use, and to adopt better maintenance methods to restore sunken fills and prevent further settlement.

A brief description of peat deposits will be necessary if any adequate idea is to be had of what actually exists under the surface of a "sink hole." Peat deposits are classified and mapped stratigraphically in essentially the same way as mineral upland soils. For general peat studies, peat materials have been described by layers in terms of composition, texture, structure, and color. This gives a fairly good idea of the main differences between separate peat layers and localizes their relative positions.

Varying Characteristics of Peat Layers Aid Study of Fill Settlement.—The classification of peat strata was made in accordance with the system largely developed in this country by Dr. Alfred P. Dachnowski, of the Bureau of Plant Industry, United States Department of Agriculture, and he personally supervised a number of surveys. The following description of peat deposits is taken from an article on the "Stratigraphic Study of Peat Deposits" by Doctor Dachnowski. "Distinction should early be made between muck and peat. Muck is the thin surface layer of disintegrated peat and is entirely different in appearance and properties to the relatively unaltered peat below it. This distinction is made because many engineers use the terms interchangeably with no knowledge that there is a difference in the two."

Table I is from the article just referred to, and gives the classification of characteristic peat layering.

Pulpy peat is formed in water basins under conditions of poor drainage from transported organic sediment carried from its origin and redistributed by water currents. There are no visible bedding planes although the original sediment was laid down in practically horizontal position under conditions differing by rate of deposition, seasonal changes, etc. The plant remains are small in size. In texture the peats vary from coarse to very finely divided particles, while in structure a layer may vary widely in its degree of compaction. Fresh from the deposit and while still moist the colors vary from gray, green and brown to black.

As with most peats, the pulpy variety quickly loses its character by oxidation on exposure to the air and drying. It shrinks enormously and becomes a hard, water-resisting substance when quickly dried out. It will not then absorb anything like the original quantity of water. Doctor Dachnowski states that "it may be accepted as an axiom that undrained deposits of peat contain from about 70 to 95 per cent of water."

The outstanding characteristic of fibrous layers of peat is their matted or felt-like, porous nature which has its origin in the slightly altered remains of moss, roots, rootlets, and rhizomes of herbs. The peat layers differ widely in character. Their water content is enormously high, the solid matter commonly composing only from 5 to 15 per cent of the peat mass. In texture they vary from coarse to very finely fibered material usually presenting a rather loose, porous appearance, with colors ranging from gray through yellow to red brown and dark brown. The layer may be interbedded or it may grade into a layer of woody pulpy peat by admixture or it may occur in overlapping beds of other kinds of fibrous peat.

Woody peat may occur either as the dominant components or as a prominent admixture in other types. The woody plant remains are broken down partly into granular debris and partly into irregularly shaped woody fragments, which are almost unaltered by decomposition. The woody peats differ widely in composition and character. They may be as finely divided as sawdust or as coarse as a tangle of waterlogged brush and logs. Several layers may be found as, like the fibrous peats, they are developed on moist flat land under conditions of a rising or fluctuating water table. Land may grow up to forest, be submerged to form a marsh, and then emerge again to become a forest. In one peat deposit examined on this survey three distinct forest layers were plainly visible.

Marly phases of peat are formed from calcareous plant remains and shells of mollusks and are usually found admixed in the macerated types of peat. Extensive deposits of marl with peat occur mainly in regions underlain by limestone rock or where the soil adjacent to and underneath a peat area is derived from limestone drift. Deposits vary in color from gray to brown, and are usually soft plastic masses with particles from fine to comparatively coarse, depending on the amount and character of plant or shell remains present.

The lake clay found at the bottom of most deep peat deposits is structureless, mainly siliceous material from plant and animal remains consisting of diatomaceous shells and drift debris. It is gray to gray blue in color, fairly compact, but with a high percentage of water in it and is quite plastic and sticky. It is, however, a much more

Table I—Structural Units of Peat Deposits and Some of Their Physical Characteristics

Groups of peat-forming vegetation	Types of peat	Character of peat layers	Color of peat layers	Texture of peat layers	Structure of peat layers
Aquatic	Macerated Colloidal	Pulpy (sedimentary)	Olive green, brown to black.	Coarse to very finely divided.	Compact, impervious, stiff, plastic or loose, friable.
Marsh	Reed Sedge Brown moss	Fibrous	Gray, red or yellow brown to dark brown.	Coarse to fine fibered	Dense, matted, felty, or porous, spongy.
Bog	Bog moss Heath shrub				
Swamp	Willow-alder shrub Deciduous forest Coniferous forest	Woody	Dark brown to blackish brown.	Coarsely fragmented to granular.	Compact and granular, or loose, wicker-like.

compact and weighty material than any of the peats or marls.

In carrying out the study of fill settlement it was decided to cross section marshes accurately by borings, which would show the various peat layerings and the exact position of the filled material with reference to them. Samples of the various classes of peat were to be collected and set to the laboratory for physical tests in an effort to discover some relationship between their bearing

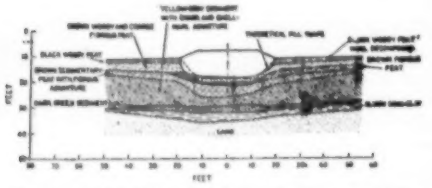


Fig. 1.—Fill of Normal Cross Section in a Peat Marsh about 22 Ft. Deep From Surface to Clay.

power and the known settlement for various water contents. If a large number of existing fills were thus examined, it seemed logical that general conclusions might be drawn to serve as a guide on future work.

Fill Settlement Not Affected by Character of Peat.—Fills over eight different peat deposits were cross sectioned at 83 different points where the depth of the peat ranged from 1 to 66 feet. The shape of the fill material was accurately determined with a 2-in. Empire drill. Cores from the peat were taken with the Davis peat sampler where possible, but if the peat was compacted beyond a certain amount of the Empire drill and jet was used. Enough test holes were put down on the cross section chosen to show the fill shape fairly accurately and an effort was made to extend the cross section in both directions from the fill sufficiently far to get out of the zone where the layers were disturbed by filling. In a few cases it later became evident that the test holes at the extremities of the cross section were not placed far enough from the center line.

Samples of the different peat layers were collected at various depths and sent to the laboratory for physical tests. Results were very disappointing in this regard. It was impossible to maintain the peat in its original condition on exposure to the air. Peat as it comes from the ground is only partially oxidized and at the greater depths there is actually some reducing action. Consequently, immediately it is handled in air, oxidation begins and if it is attempted to dry it, a totally different material results. Laboratory bearing value tests were not satisfactory. It is certain that the amount of compression under loading in a vessel such as is used in the standard bearing value test which does not permit of a free displacement in all directions will not give results at all indicative of the behavior of the same material in its natural place.

The only way, then, to secure the solution of the various problems involved in this study was by a careful study of the cross sections showing the fill shape and the peat layerings in the disturbed position after filling. An effort was made to reconstruct the position of the layering as it originally existed from the position of the layers outside the distorted area of the cross section. A study of the fill cross section and the distortion of the original layers as reconstructed led to the conclusions drawn from these effects.

The various factors which it was thought should determine the amount of settlement were depth and character of peat layering, height of the water table, slope of the mineral subsoil beneath the peat, height and width of fill. The weight and character of the fill material would also be a factor but the difference in weight of the materials studied was so small as to be neglected. All fills in this investigation were earth and varied from a clay to sand. No rock fills were studied.

So far as could be determined the character of the peat layering is very slightly responsible for differences in

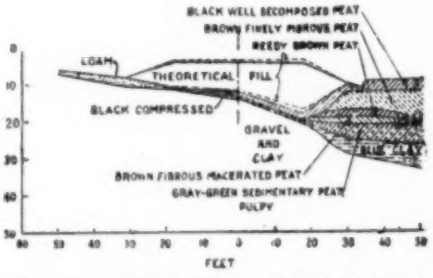


Fig. 2.—A Fill Partly on Upland Soil and Partly on Peat Marsh.

fill settlement. There is, to be sure, a decided difference between the top layer of peat a foot or two in depth where the material is fairly well decomposed, but this is due more to a smaller water content than in the actual character of the material itself. The lake clay which occurs in the bottom of most of our deeper peat deposits is enough different in character to make it necessary to consider its effect separately. It is also probable that if any considerable thickness of pure marl with a heavy texture were encountered it should be grouped with the clay or given separate treatment. As it happened in this investigation no very great amounts of marl were found except as they occurred as a peat admixture. A soft soupy marl should probably be classed as peat in considering its effect on fill settlement. The preliminary work of sounding a peat bog preparatory to estimating fill settlement is thus considerably simplified for the engineer, as where a uniform marl is absent, only two layers, the peat and lake clay, need be considered. No differentiation of peat layering is necessary for estimating fill settlement.

Depth of Peat and Lake Clay the Most Important Factors.—If there were any great variation in the height of the water table compared to the depth of the deposit, this factor should certainly show its effect. It so happened that the road ditches were about the same depth through all of the shallow peat deposits studied and in the deposits of greater depth the depth of the ditch was very small in comparison to the total depth of the peat. The water table in most cases varied from 1 to 3 feet below the fill surface. The varying height of water table, which was to a certain extent dependent on the time of year as well as on the particular situation of the cross section, was not taken into account. Some inconsistencies in the shallower depths are probably due to the neglect of this factor.

The height of the fill above marsh surface is of course a factor, although not so great a one in the case of loading over a wide area as one would expect. In peat depths of less than 10 feet the settlement is small and is affected by factors other than height of fill and results are inconsistent. The height of fill produces a marked effect in medium depths of peat of from 10 to 25 ft. In depths beyond 25 ft. the total depth of fill is so great in proportion to the height above marsh surface that the amount of this additional loading is not important. The above refers to completed fills studied and not to new construction methods in which the height of fill placed in the early stages is of considerable importance.

The slope of the mineral subsoil produces a marked effect on settlement and the bottom of the fill nearly always takes the same direction of slope as the marsh bottom. This is due to two reasons; first, the flow of peat beneath the fill is aided by gravity, and, second, the greater depth of peat down slope induces greater settlement. Most of the

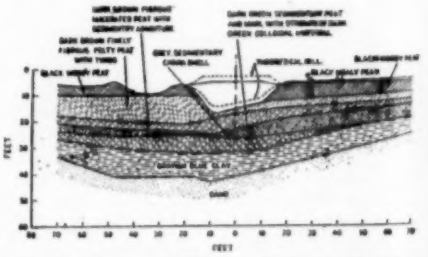


Fig. 3.—Shape of Fill in Peat Considerably Affected by Slope of Mineral Soil at Bottom of Peat Bed.

inconsistencies in amount of settlement from the determined normal occur above sharp slopes in the mineral subsoil. The amounts varied so much, however, that no general law could be observed. It is safe to say that in general if the mineral subsoil does slope quite sharply, the normal amount of settlement will be increased.

One very important factor met in special cases is the effect on fill settlement of the peat compression by neigh-

boring fills. The compresesd peat is much more resistant to flow than is the uncompressed peat, and hence flow on the side adjacent to an old fill is very much smaller than on the free side.

The factors of greatest importance and the ones least difficult of determination are simply the depth of the peat layer and the depth of the lake clay beneath it. Other factors undoubtedly have their influence but the depths alone, so far as could be determined from the information available, directly determine the amount of settlement which will occur. No other factors operated with the consistency or effect of these.

What Happens When a Fill Is Placed Over a Peat Deposit.—Let us consider what happens when a fill is placed over a peat deposit. The top crust is first subjected to compression beneath the interior of the fill and to shear and tension at the edge. The communication of this compression to the interior of the peat is opposed by the resistance to flow of the peat or its internal friction. On account of the inertia of the peat particles, water is squeezed out of the material nearest the fill and the material is compacted, and this process extends with continually decreasing effect as distance from the fill increases until at some distance the peat is practically undisturbed.

Lateral flow of peat begins at an early stage in the placing of a fill and is due to the horizontal component of pressure due to the internal friction of the material and also to the inclined position of the settling load. Peat is forced outward and upward, until in the course of time a condition of equilibrium is reached.

It is easily understood, then, that the width of fill is a function of the amount of settlement which takes place. The fills in this investigation do not vary

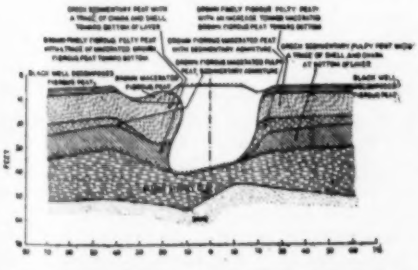


Fig. 4.—Distortion of Peat Fill to Left Due to Slope of Firm Soil Beneath Peat Bed.

greatly in width, viz, from 24 to 30 ft., and so no account is taken of this factor. It is important, however, in considering the cause of the greater settlement in deeper deposits.

When deposits are relatively deep in proportion to their width, considerable vertical movement can take place before any marked reaction is experienced from the mineral subsoil below. In this case, lateral flow is comparatively small at first and a large amount of settlement is possible before there is much resistance; the elastic crust ruptures in tension and shear and the whole weight of the fill is suddenly thrown on the soft material below. This sudden application of weight very quickly compacts the peat below to a degree at which lateral flow begins in a considerable amount and we have a "sink hole." A portion of the peat flowing from beneath the load of earth is forced up at the sides. Due to the lighter weight of the peat as compared to the fill material, a correspondingly larger amount of peat must be raised to balance the heavier fill. Subsequent loading increases this heaving until the weight of the heaved peat brings about a condition of equilibrium.

Slope of Soil Beneath Peat Bed Affects Fill Shape.—In the later stages of fill settlement the rate of settlement is very slow, but even a rate of a foot a year is decidedly objectionable. The rate progressively decreases until finally, after a long time, equilibrium is established. The length of time required to reach a stable condition in some cases is known to have been more than five years. We have arbitrarily

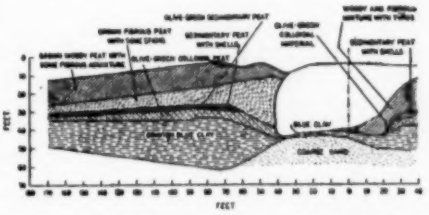


Fig. 5.—Fill Adjacent to Railroad Fill at Right Cut Not Shown. Compacted Peat on Right Side Reduced Amount of Fill Considerably.

established the rate of five-hundredths of a foot in 30 days as being the rate of settlement at which filling may be stopped. Since the rate will usually decrease progressively, this should give a settlement of less than 6 in. per year.

Unfortunately, at times, if the early settlement is not rapid, some later causes may accelerate the rate of settlement. Fills completed in the fall under earlier methods were quite apt to settle rapidly the following spring. The vibration of traffic also tends to increase the rate of settlement after a road is first opened. Large ditches cut along an old road are quite apt to start considerable settlement. As a matter of fact, unless settlement during filling has been accelerated in order to insure its completeness, some subsidence is almost sure to take place later.

A number of cross sections illustrating the various shapes taken by fills under different conditions are shown. Figure 1 shows a fill of normal cross section in a peat marsh about 22 ft. deep from surface to clay. The theoretical shape of fill is shown by the dashed line and is obtained by a method described later. This deposit is of nearly equal depth on both sides of the fill and therefore the shape of fill is quite regular.

Figure 2 shows a fill which is partly on upland soil and partly over peat marsh. It will be noticed that the mineral subsoil slopes sharply toward the peat deposit and for this reason the proportion of the fill beneath the surface of the peat is considerably increased above that shown on the normal cross section. It will also be noticed that on account of the

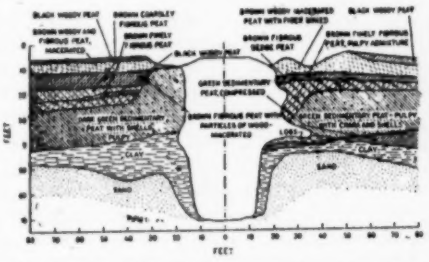


Fig. 6.—An Unusually Deep Fill. Soundings Would Have Indicated This Condition and Permitted More Advantageous Location.

flow of the material only a very small amount of the peat remains under the fill, and that the layers to the right of the fill are considerably thickened by reason of their flow from beneath the fill and subsequent expansion due to the decrease of pressure.

Figure 3 shows a fill which is still settling into the peat marsh at a rapid rate. The slope of the bottom of the fill is quite noticeably parallel to the slope of the mineral subsoil beneath the light clay and most of the distortion of the peat layers has occurred on the low side of this mineral subsoil. It is quite evident that even with this considerable depth of peat beneath the fill, pressure is communicated throughout the entire mass.

The effect of the slope of the mineral subsoil upon the direction of pressure is still more marked in Figure 4, where it will be noticed that, except immediately adjacent to the fill, practically all of the disturbance of the peat has taken place to the left of the center line, indicating that flow has largely occurred in this direction.

Figure 5 shows a fill which was placed adjacent to a railroad fill at the right, but not shown in the figure. In this instance it will be noted that the compacted peat to the right of the center line reduced the amount of fill necessary in a material manner. A very considerable amount of distortion of the layers is shown on the left of the figure. In this instance the peat is heaved above the normal level of the marsh some 10 or 12 ft. and slopes away from the crest of the heaved material in a fairly uniform manner.

Figure 6 shows the deepest cross section encountered in this investigation, a fill with a depth of about 66 ft. The marsh, over which this fill was made, lies between two fairly large lakes, which are at present connected

by a small stream. It is quite evident that the location of the highway in this particular instance was very unfortunate in that the center line of the highway at the cross section shown is practically on the center line of the old glacial drainage channel between the lakes in the early stage of their formation. A location of center line 30 ft. to the right of its present location, which would have been possible, would have eliminated about 25 ft. of fill. The entire amount of the lake clay which probably nearly filled the old channel, has been forced to one side by the load of fill above it. The irregular shape of the cross section on the right is probably due to filling a hole left by the peat heaving 8 or 10 ft. at the side during construction.

Method of Predicting Fill Settlement and Shape Developed.—From the whole series of cross sections of the character of those illustrated, most of which, however, are considerably more regular, diagrams giving the amount of settlement and shape of fill have been prepared. Depths of peat and marl on center line of fill were platted against

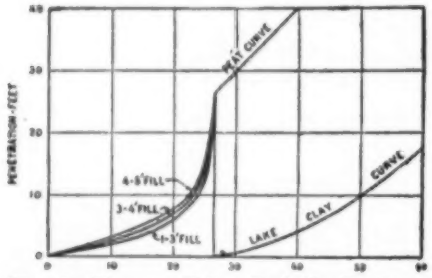


Fig. 7.—Diagram Giving Probable Depth of Penetration of Fills in Peat Marshes.

the total depth to which the fill penetrated the peat and marl as measured from the original marsh surface. Three curves were then drawn, one representing the average of fills with a height above marsh level of 1 to 3 ft., one for 3 to 4 ft. fills, and the third for fills from 4 to 5 ft. in height. These three curves, shown in Fig. 7, indicate that the amount of settlement increases uniformly but is not great up to a marsh depth of 20 ft. As the marsh depth increases from 20 to 26.5 ft. the settlement increases rapidly and when the depth exceeds 26.5 ft. the fill goes completely through the peat in every instance, so that the penetration is equal to the depth and the three curves become common and make a straight line with a slope of 45°. Therefore, for peat and marl depths of less than 26.5 ft. the depth of lake clay need not be taken into account, except as a factor should settlement be different from the average, and anticipated settlement is read directly from the diagram. For depths of peat and marl over 26.5 ft. the settlement will probably be the full depth of the deposit plus some penetration into the lake clay. The amount of penetration into the latter material is read directly from the curve marked lake clay, which has been plotted, using the combined depth of peat and clay as abscissas.

Suppose we have a peat marsh consisting of 30 ft. of peat and marl and 5 ft. of lake clay. The peat curve gives us complete penetration of the full 30 ft. of peat and from the 35 ft. total depth of the marsh deposit we read off from the clay curve 2 ft. for clay penetration. There will then be a distance from bottom of fill to marsh surface of 32 ft. Again, if we had a peat deposit consisting of 38 ft. of peat and 2 ft. of lake clay we should get 38 ft. of peat penetration plus 4 ft. of clay penetration. The total, 42 ft., exceeds our total depth of deposit and the fill therefore stops at the marsh bottom with a 40-ft. penetration. This last case is not common except in the very deep deposits, of 50 ft. or more. It will usually be found that in marshes of such extreme depth with ordinary proportions of peat and lake clay, the fill goes to the very bottom.

No claim of scientific reason is made for the shape of the curves shown in Fig. 7. They are purely empirical and represent merely the average behavior of a considerable number of fills. Extreme variations of actual from expected settlements as derived by this method have been found to be as much as 100 per cent for an indicated settlement of 5 ft., 60 per cent for 10 ft., 30 per cent for 20 ft., 20 per cent for 25 ft., 10 per cent for 30 ft., and less for greater amounts. Generally accuracy of the method is well within these limits.

The method of estimating fill quantities is illustrated by Fig. 8. The typical shape shown was arrived at by drawing on cross-section paper all cross sections of equal depth, superimposed on each other, with the marsh level as a base line, and then fitting an average shape to them. A side slope of embankment above marsh level of 1 to 3 ft. was used, since most of the fills studied had this slope. The fills quite generally slope inward from the outermost point of the embankment to a point directly beneath the shoulder line. The total area of fill is composed of two trapezoids and can be calculated by the following formula, the symbols representing distances as indicated in Fig. 8.

$$\text{Area} = (W + 3F)\ (F + H)$$

In each case H must be determined by use of the curves shown in Fig. 7. In Fig. 8 the bottom of the predicted shape of fill is shown as a horizontal line and this was very nearly the case in most instances, the center of fill being only slightly lower than the outside. The depth of penetration, as indicated by Fig. 7, takes account of these variations and gives the average depth to the bottom of the fill.

Fill Settlement Should Be Accelerated.—It may be surprising to note that the slope of the fill sides beneath the surface of the peat is toward the center of the road, but, with a little consideration, the reason for this is quite apparent. In the first place, the fill load as placed varies from zero at the toe of slope to its maximum at the shoulder line, and hence should produce a fill shape corresponding to this loading. Also, in a good many instances the fill has been carried across the marsh at less than full width while heavy settlement was taking place, and this produced a narrower fill at the bottom. Undoubtedly the drag of the compacted peat at the side also tends to narrow the fill width as it sinks. This is indicated by the fact that the center is quite generally lower than the rest of the cross section.

One of the striking features of this investigation was the irregularity shown in the topography of the marsh bottoms. In a number of instances a slight shift in line would have saved thousands of yards of earth in filling. It is therefore necessary when the location of the road requires the crossing

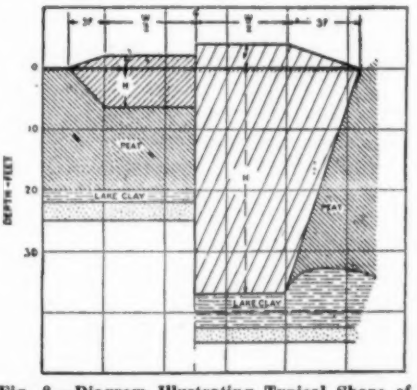


Fig. 8.—Diagram Illustrating Typical Shape of Peat Fills for Use in Estimating Earthwork Quantities.

of a peat marsh to map the topographical features of the marsh bottom quite accurately. This is more important than on upland soil because visual inspection of the proper location cannot be made but must be determined by the topographical information secured from sounding.

In places where there is any considerable depth of peat it is highly necessary that settlement during filling be encouraged in every way possible. This settlement is bound to take place sooner or later, and it is important that it be practically complete before any rigid surfacing is placed. Construction of brush mats to float the fill is not advisable in the case of highway work where hard-surface pavement is to be placed. These mats only delay settlement and do not stop it. This is contrary to the practice of some railroads, but in railroad work it is a simple matter to add ballast and bring the track back to grade as settlement progresses without interrupting traffic. In case of any considerable settlement on a hard-surfaced highway, the sub-grade must be

refilled and a new surface placed. This always involves more or less interruption to traffic besides the greater expense of placing the new surface.

The length of the bog should be considered in choosing a method of filling. Settlement over short bogs, even in small amounts, is much more objectionable than on longer stretches because of the sharper deflection of the settled surface, and the liability to offsetting of the pavement slabs. A long gradual settlement of considerably greater amounts is not so noticeable either to the eye or in the riding qualities of the pavement. Of course, settlement over either long or short bogs is objectionable if the amount is great enough to interfere with the drainage. Settlement sufficient to cause trouble on this account is not likely to occur in marshes of less than 6 ft. in depth.

Standard Methods of Filling Developed. — Figures 9 and 10 illustrate methods of filling over peat bogs now standard with the Michigan State Highway Department, one or another of which is used depending upon the length and depth of the bog to be crossed. Method No. 1 simply consists of placing the fill on the peat surface and is used where the marsh is less than 6 ft. deep, more than 300 ft. wide and undrained. The bog is long enough so that, if settlement should take place, it would be rather gradual, and the 24-in. height of fill above the original marsh will usually absorb this settlement without bringing the top of fill too close to the marsh surface.

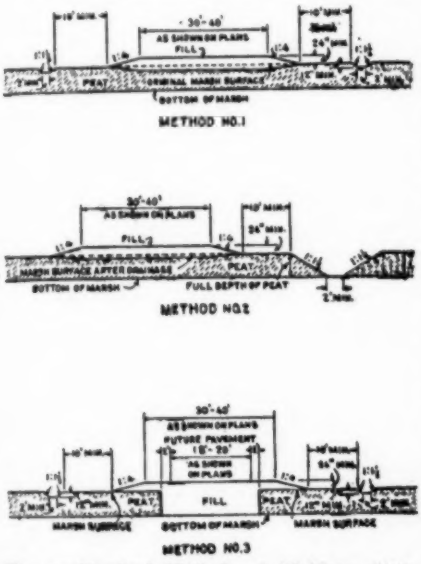


Fig. 9.—Standard Methods of Michigan State Highway Department for Filling Over Peat Bogs.

Method No. 2 is used in drained peat marshes up to 6 ft. in depth and over 300 ft. in width. It is similar to method No. 1 except that the marsh drainage ditch goes entirely through the peat deposit. The ditch is excavated prior to the placing of the fill. This type of construction results in a much drier subgrade, and the lowered water table helps to prevent considerable settlement. This scheme should be used where conditions of the marsh drainage system require the use of ditches of considerable size.

Where bogs are less than 300 ft. in width, and not more than 6 ft. in depth, and even small settlement is undesirable, method No. 3 is used. This method requires that all the peat to a width 4 ft. greater than the proposed pavement slab be excavated to marsh bottom, and the excavation filled with good earth. This method is not so expensive as it would seem, because the peat is very easy to move and can usually be disposed of with a very short haul. Peat excavation of this type is not practical for depths greater than 6 to 8 ft. on account of the large amounts of peat which slide into the hole from the sides.

The above methods are not suitable for bogs much in excess of 6 ft. in depth. In the deeper deposits settlement is almost sure to take place and should be aided while the fill is being placed. Method No. 4 in Fig. 10 illustrates a Michigan practice in deposits over 6 and less than 20 ft. in depth. In the first stages, two narrow fills, spaced 16 ft. on centers, are carried across the marsh.

The supporting power of the peat crust is destroyed by blasting on the center line of each of the fills. The trenches thus made are backfilled with earth in 4-ft. lifts and carried simultaneously across the marsh, trapping a certain amount of peat between the two fills. When the first two lines of embankment are complete and settlement has slowed up to a considerable extent, charges of dynamite are placed in the peat on 4-ft. centers, from 2 to 3 ft. below the bottom and on the center line of each embankment, and exploded. This second blasting drives the peat from beneath the wedges of earth and induces further rapid settlement. After refilling the settlement caused by the shooting, the second loading of earth is added in a 4-ft. lift on the center line of the road. This second loading helps drive the wedges of earth still farther into the peat and insures a maximum compaction in the center so as to eliminate the possibility of center settlement resulting from the method used in the first loading. This loading is maintained by refilling the settlement until the rate of settlement is less than five-hundredths of 1 ft. in 30 days. The excess earth is then spread to form the complete embankment.

Bogs from 6 to 20 ft. in depth usually give more trouble than any others, because they rarely settle rapidly, unless excessively loaded, and surfaces are laid on fills long before complete settlement has been attained. It is much more difficult, in bogs of these depths, to secure complete settlement due to the early resistance of the peat to compaction; and it is for this reason that the two narrow wedges of earth are used, the effort being to secure as deep a penetration as possible. The final loading under this scheme gives a static load which is nearly swice the normal load, and it is felt that little danger of further serious settlement need be feared. To insure the acceleration of settlement, it is required to maintain the grade to within 1 ft. of the designed elevation at all times.

In long marshes, in order to avoid long backing by trucks in end dumping, provision is made for shooting part of the fill at a time. It is believed, however, that at least 100 ft. of fill should be held for settling at all times before any shooting is done.

For depths of peat over 20 ft., the center loading is used at once after the surface of the peat has been broken up by dynamite. A fill 12 ft. wide at the top and 4 ft. high is carried across on the center line. This fill is maintained at grade as nearly as possible until it is entirely across the space over which this method is to be used. As soon as it can be maintained at grade entirely across the marsh, a second 4-ft. lift is made without any preliminary shooting. It is felt that with a fill width of this amount, dynamite would not displace the peat sufficiently to justify its use. In addition to this, the greater depth of the marsh makes settlement so much easier that the loading alone produces sufficient settlement. After the settlement has slowed down to a rate of five-hundredths of 1 ft. in 30 days, the fill is unloaded and the excess material spread to form the remainder of the cross section. The compressed peat on both sides of the narrow fill will usually support the additional width with little settlement.

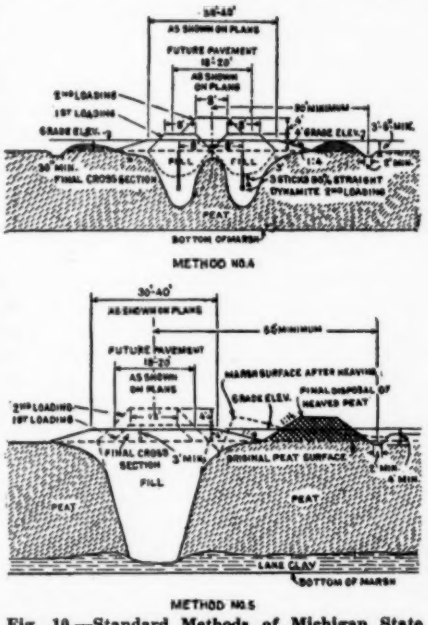


Fig. 10.—Standard Methods of Michigan State Highway Department for Filling Over Peat Bogs.

Any combinations of these methods may be used in crossing peat marshes

of considerable length, suiting the method to the depth and width. The first requirement in all marsh filling where pavement is to be placed is to insure settlement, and not attempt to avoid it. Unless the fill has become stabilized, this settlement may occur over long periods and the former practice of attempting to "sneak across" with light loadings has been responsible for a great deal of maintenance expense in locations of this character. The proper time to take care of this settlement is during construction, as it is extremely difficult to maintain in a satisfactory way a surface which is continually settling.

Fill Construction Should Precede Bridge Construction.—If any bridges are to be placed over streams through deep peat deposits, the approaches should always be completed first. Filling should continue toward the center of the stream so that excavation for footings will occur in the filled earth. In some cases, where streams are small, it will be found advisable to carry this filling completely across the old stream bed. The expense of later cleaning out the earth above stream bottom and taking care of the stream flow during filling is money well spent.

The above may seem ridiculously obvious to many engineers, but the frequency with which bridge failures have occurred during the past because of ignorance of the troubles which may arise through neglect of this item justifies it. When a bridge rests on piling with lengths of over 10 ft. penetrating soft peat before hard bottom is reached, the bending stresses induced in the piling during backfilling can easily cause failure where sufficient penetration of the mineral subsoil can be had to give a good piling anchorage. If penetration of the piling is limited by a hardpan layer below the peat, sliding of the bottom of the piling may take place. If the deposit is deep, the piling may be flexible enough so that it acts as a cantilever fixed at the bottom and the whole structure may be moved in one direction. The forces due to the compression and flow of the peat during filling have been the cause of a number of bridge failures.

In one case in Michigan in 1916, a 40-ft. bridge was put in, supported by 50-ft. spliced piling. Some time after filling of the approach was started the bridge began to move, slid along the axis of the roadway and inside of a week had completely disappeared from sight. In another case in a peat deposit about 40 ft. deep, a 40-ft. bridge rotated about 5° about one end, and settlement then began in sufficient amount to destroy the bridge. Had the approach fills been made first, these failures would not have occurred.

The maintenance of a road surface which is settling is a comparatively difficult matter to handle. In a number of cases where the amount of settlement was not over a foot or two and a concrete surface had been placed, the slabs have been jacked back to grade and the space beneath the slab refilled with tamped earth. It is for this reason that mesh reinforcement is desirable, as it has been found that reinforced slabs can be jacked back into place with very much less breakage than the plain slab. In other cases, where the settlement has been accompanied by considerable slab breakage, it has been necessary to remove the surface, bring the fill back to grade, and replace the surface. Where the amount of settlement is considerable it may be possible to effect a remedy by removing only a part of the pavement at each end of the settlement and placing new sections which will join the sunken slab properly to the surface adjacent to the settlement.

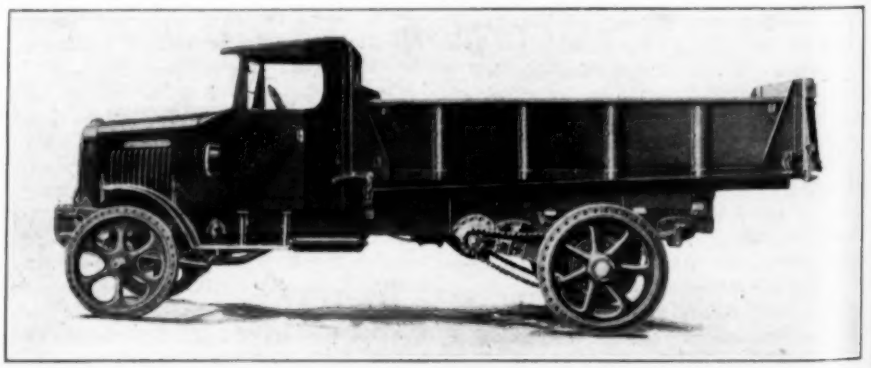
It is unfortunate that the present methods of filling have been used for so short a time, as it is impossible for us to accurately estimate the amount of filling material necessary with methods 4 and 5. Quantities in each case will be less than those indicated by curves derived from an investigation of fills which have been placed full width on the surface of the undisturbed peat. It is planned in the near future, as soon as a sufficient number of these examples are available, to cross section and determine the amount necessary, using the new method. We are confident that the methods proposed will eliminate a great deal of the settlement formerly encountered, and will involve the use of smaller amounts of material in filling.

New Chain-Drive International Trucks

Two new types of 4-cylinder dump trucks with nominal ratings of 2½ tons and 3½ tons respectively have recently been added to the already very complete line of motor trucks manufactured by the International Harvester Co. The smaller of these, designated as Model 54-C, has a capacity of from 2½ to 3 yd. and the larger, designated as Model 74-C, 4 to 5 yd. Both models are provided with a wide range of gear ratios so that when necessary a maximum of power can be exerted in pulling up steep grades and at other times a fair rate of speed with a minimum of fuel consumption can be attained on level and easy-going stretches. The transmission includes four speeds forward and one reverse. In the larger Model 74-C truck, in addition to the reduction gear type of drive, the live axle has a two-speed range, which provides an exceptionally wide choice of power applications.

A very simple arrangement for adjusting the tension of the chains is incorporated in the steel radius arm, which transmits the torque from the rear wheels to the frame. Adjustment is stated to be so easy that liability of neglect of chains is greatly reduced and hence danger of undue wear on chains and sprockets resulting from the chains running too tight or too loose is considerably lessened.

Removable cylinders; worm and wheel steering gear, with post carrying wheel at a 30-degree angle and connecting shaft vertical, thus giving maximum foot clearance, comfort, and convenience for the driver; and auxiliary rear springs that go into action after the load reaches a certain amount, thereby providing additional cushioning effect when loads are heavy, are features which are retained in the new chain-drive models. The frame consists of deep double steel channels, one inside the other, each section being ¼-in. thick, and a liberal number of cross members that give the entire chassis great rigidity.



New Model 74-C International Chain Drive Truck.

Examinations for Draftsmen.—The U. S. Civil Service Commission, Washington, D. C., announces the following open competitive examination: Principal topographic draftsman, $2,100; topographic draftsman, $1,680; assistant topographic draftsman, $1,500; junior topographic draftsman, $1,320. Applications for these positions must be on file with the Civil Service Commission at Washington, D. C. not later than March 22. The examinations are to fill vacancies in the Departmental Service, Washington, D. C., and in positions requiring similar qualifications throughout the United States.

Federal Aid Road Construction

The Progress Outlined in the Annual Report of the U. S. Bureau of Public Roads for Fiscal Year Ending June 30, 1926

By THOS. H. MacDONALD
Chief, Bureau of Public Roads

The Federal-aid road projects completed during the fiscal year contributed a net addition of 9,417.3 miles to the mileage of improved roads in the Federal-aid highway system. Added to the mileage improved with Federal assistance in previous years, the above brings the total length of improved Federal-aid roads up to 55,902.8 miles.

At the close of the year construction was in progress on 10,961.8 miles and projects involving the improvement of 2,469.5 miles additional had been approved. Including the mileage of projects in these latter stages, all of which is included in the Federal-aid system, the total mileage improved or in process of improvement with Federal aid was 69,334.1 miles. With the exception of a few hundred miles improved prior to the designation of the Federal-aid highway system in 1921, all of this mileage is included in the system.

182,134 Miles in Federal-Aid System.—The highways included in the system now have an aggregate length of 182,134.8 miles. All have been selected by the constituted State and Federal highway officials as essential links of a system adequate for the accommodation of interstate traffic. Naturally there are degrees of importance even among these selected roads, but compared with the 3,000,000 miles of other highways in the country they are the most important of the nation's highways and their improvement is absolutely essential for the proper accommodation of interstate highway traffic.

It is entirely consistent with the interests of the Federal Government to participate in the improvement of every mile of the designated system, but that will not be necessary. With negligible exceptions the roads included in the Federal-aid system are also parts of the several State highway systems. This is inevitable from the fact that important interstate roads are almost invariably essential State arteries also; and because of its importance to the States a very considerable mileage included in the system had already been improved prior to its designation.

The net mileage requiring construction in order to complete the improvement of the system, has, therefore, always been considerably less than the mileage of the system, and the work of improvement has always been carried on by the States independently as well as in co-operation with the Federal Government. In fact, as shown in Table I, the State reports indicate that the mileage independently improved is in excess of that improved with Federal assistance; so that it is probable that the mileage within the system at present initially improved or in process of improvement is not far from three-quarters of the total.

It is, however, not the intention to imply that the work of improvement is three-quarters done. Much of the betterment that has been effected is merely the first step toward the improvement that will ultimately be required. Of the nearly 56,000 miles improved with Federal aid nearly 10,000 miles are unsurfaced, the improvement consisting merely of the proper grading and draining of the roadbed. An additional large mileage is surfaced with sand-clay and gravel.

Table I.—Federal-Aid Mileage Completed During the Fiscal Year 1926, Including Original and Stage Construction, Compared with Total Mileage Completed in 1925 by the State Highway Departments

Group of States	Federal-aid mileage (original and stage construction) completed, fiscal year 1926 miles	Mileage completed by State departments, 1925 miles	Ratio of Federal aid to State program Percent
New England	161.4	631.0	25.6
Middle Atlantic	785.7	1,687.4	46.6
South Atlantic	1,239.6	3,201.9	38.7
East North Central	836.8	4,321.1	19.4
West North Central	3,365.3	6,538.5	51.5
East South Central	1,046.6	1,113.5	94.0
West South Central	1,384.0	3,165.9	43.6
Mountain	1,300.6	1,483.1	87 6
Pacific	490.4	1,009.8	48.6
Total	10,610.4	23,152.2	45.9

As traffic is constantly increasing, these roads cannot long be permitted to remain as they are, and there is a definite agreement between the State and Federal agencies that they will be further improved as traffic requires and funds for the purpose become available.

The Stage Construction Policy.—All such improvements have been made in conformity with the policy of stage construction under which the condition of the highways, where traffic permits, is gradually advanced to the ultimate state of improvement with high-class surfacing or pavement by successive stages. An exactly similar policy was followed by the builders of the railroads, whose first object was to "get the traffic through," leaving until a later date the perfecting processes of ballasting, banking of curves, etc. It is the only satisfactory method of dealing with the conditions existing in many of the Southern, Middle Western and Western States in which there are thousands of miles of main road still entirely devoid of any improvement whatever.

That the purpose to continue the improvement as required is being conscientiously fulfilled is indicated by the fact that during the fiscal year secondary stages of improvement were completed on 1,193 miles previously improved with Federal aid. This work, involving the construction of 886.7 miles of gravel surfacing, 195.7 miles of concrete pavements, and smaller mileages of several other types of surfacing, is not represented in the 9,417.3 miles reported as improved, all of which was original improvement, and does not add to the total of 55,902.8 miles improved up to the close of the year. From the standpoint of the year's work, however, it does represent an accomplishment; and it may, therefore, be said that the mileage improved during the year was actually 10,610.3 miles, which exceeds the performance of any previous year except the last when 11,328.6 miles of original construction were completed.

Improvement of Transcontinental Roads Approaching Completion.—Ten years ago, when the Federal-aid plan was adopted, there were only five States in which there was a single improved trans-State highway. They were Massachusetts, Connecticut, New York, New Jersey, and Maryland, all Eastern States, and all of that small group in which the movement for better highways was begun in the nineties.

In 16 States there was then no State highway department nor the semblance of a plan for the development of through routes across the State; and even of those States in which a recently created State agency was feeling its way toward a more scientific and businesslike administration of State highways there were few in which the conception of a connected State highway system had yet been clearly apprehended.

Today 25 States have continuously improved highways entirely across them in at least one direction and 16 of these have completed such trans-State arteries in two directions.

It is the primary purpose of the

Federal-aid road legislation to expedite the continuous improvement of such cross-State highways in all States and finally to provide a completely articulated system of main interstate highways for the nation. The goal, as represented by the Federal-aid highway system, is clearly defined and progress toward it has proceeded for the last five years at least without deviation. That progress will be continued with a more pronounced singleness of purpose in the future until it shall be possible to travel by highway without obstacle in any direction across all States and throughout the nation.

Status of Transcontinental Routes.—There is now one transcontinental road which is 97 per cent improved. It extends from Washington through St. Louis, Texarkana, and El Paso to San Diego. Of its entire length 93 per cent is surfaced and 4 per cent is merely graded and drained; and of the surfaced portion more than half is improved with bituminous macadam or better and the remainder is gravel. From Washington to St. Louis there is no unimproved section and nearly 96 per cent is surfaced with bituminous macadam or some higher type of pavement. From St. Louis to Texarkana 2 per cent of the distance is unimproved and 63 per cent is improved with a gravel surface, the rest with superior types. From Texarkana to El Paso there are unimproved sections to the amount of 4 per cent of the distance, gravel surfaces 50 per cent, and bituminous macadam or better the rest of the way; and from El Paso to San Diego, with the exception of 6 per cent of the distance, the route is surfaced 60 per cent with gravel or equivalent and the remainder with pavements and surfaces of higher types.

This road from Washington to San Diego is more nearly completed than any other transcontinental route. Of its total length of 3,133 miles, 2,907 miles are surfaced and 131 miles are graded and drained, leaving only 95 miles without improvement.

Next in point of improvement is the route from Atlantic City, N. J., to Astoria, Oreg. Of its total length of 3,240 miles, one-eighth is still unimproved, nearly another eighth is graded and drained, and the rest is improved with some form of wearing surface. Of other east-and-west routes, that from Norfolk, Va., to Los Angeles is 68 per cent improved; and from Chicago to Los Angeles, partly by this same line, is 63 per cent improved. From Boston to Seattle through the northern tier of States the most direct through road is 73 per cent improved and 69 per cent surfaced either with permanent or temporary surfacing.

Types of Federal-Aid Roads.—The 9,417.3 miles involved in the projects completed during the year consist of 2,161.3 miles of graded and drained earth roads, 627.3 miles surfaced with sand-clay, 3,274.1 miles with gravel, 58.2 miles with water-bound macadam, 553.2 miles with bituminous macadam, 179.6 miles paved with bituminous concrete, 2,464.3 miles of Portland cement concrete, 78.1 miles of brick, and 21.3 miles of bridges more than 20 ft. in span.

The earth, sand-clay, and gravel roads are mainly in the South and in the States west of the Mississippi. Of the 6,062.7 miles of these three types completed during the year only 187.4 miles are in the Northern and Eastern States. The small mileage of water-bound macadam is scattered among the States of all geographic groups except the Middle Atlantic, West North Central, and Pacific; and the several higher types of construction, including bituminous macadam and better are found in all sections, forming the highest percentage of the total however in the Northern and Eastern States.

A similar sectional distribution of the several types of construction exists with respect to all highways constructed with Federal aid; and, as shown by Table I there is an appropriate relation between the types constructed in the various geographic sections and what may be termed the potential motor vehicle traffic as represented by the ratio of motor vehicle registration to mileage of the Federal-aid system in each section.

Table II.—Relation of Potential Motor Vehicle Traffic and Types of Federal-Aid Roads Completed to June 30, 1926

Geographic division	Number of motor vehicles per mile of Federal-aid system*	Percentage of mileage of roads completed: Bituminous macadam and higher types	Percentage of mileage of roads completed: Water-bound macadam and lower types
Middle Atlantic	343	98.5	1.5
New England	223	70.8	29.2
Pacific	193	35.2	64.8
East North Central	187	70.3	29.7
South Atlantic	85	35.9	64.1
West South Central	74	21.8	78.2
West North Central	62	14.2	85.8
East South Central	61	25.5	74.5
Mountain	32	9.5	90.5
All States	109	31.4	68.6

* As registered in the several States during the calendar year 1925.

In Table II the several geographic divisions are arranged in the descending order of the ratio of their motor vehicle registration to the mileage of the Federal-aid highway system in each; and it will be observed that with the exception of the Pacific and East South Central groups the several divisions would be rated in the same order on the basis of their percentage of mileage suitable for medium and heavy motor vehicle traffic.

In addition to the 9,417.3 miles of original construction completed during the year, stage construction was completed on 1,193 miles, all of which had been previously constructed to lower type with Federal aid. This secondary construction was divided by types as follows: Sand-clay, 7.8 miles; gravel, 886.7 miles; water-bound macadam, 6.8 miles; bituminous macadam, 46.3 miles; bituminous concrete, 49.5 miles; Portland cement concrete, 195.7 miles.

That this process of gradual improvement is being continued at a desirable rate is indicated by the fact that stage construction was in progress on 1,328.9 miles, including 943.6 miles of gravel, 75.3 miles of water-bound macadam, 36.5 miles of bituminous macadam, 44.9 miles of bituminous concrete, 227.8 miles of Portland cement concrete, and 0.8 mile of brick.

Both in mileage of stage construction completed and in mileage under construction the West North Central States led all other groups by a wide margin, the Mountain and South Atlantic States being next in order. No work of this character has been undertaken in the New England or Middle Atlantic States and only a relatively small mileage is in the East North Central States. From Table I it will be observed that these are the groups in which the original construction is predominantly of the highest character, and in which there is consequently the least need for further improvement.

In view of the general increase in motor-vehicle traffic throughout the country it is interesting to observe from Table II that the greatest increase in mileage was of those types, including the gravel, bituminous, and pavement types, which are most suitable for motor-vehicle traffic.

Table III.—Mileage of Federal-Aid Highways at the Close of the Fiscal Years 1925 and 1926 and Percentage of Increase

Type	Mileage at close of fiscal year 1925	Mileage at close of fiscal year 1926	Percentage increase during fiscal year 1926
Graded and drained	9,079.2	653.7	6.3
Sand-clay	4,446.3	926.2	10.8
Gravel	18,013.8	22,547.3	25.1
Water-bound macadam	1,032.2	1,123.3	8.8
Bituminous macadam	2,564.2	3,176.3	23.8
Bituminous concrete	1,370.5	1,626.1	18.6
Portland cement concrete	9,234.6	11,976.6	29.8
Brick	644.2	752.0	16.8
Total	46,385.0	55,781.5	20.2

The types least suitable for motor-vehicle traffic are the graded and drained earth roads, and those surfaced with sand-clay and water-bound macadam; those pre-eminently adapted to such traffic are the bituminous types, concrete and brick. Although the new construction of the first groups amounted to 30.3 per cent of the total new mileage, the net addition of mileage of this character was only 12.2 per cent of the total net increase; the net increase of the types most suitable for motor traffic was 39.5 per cent, although the new mileage of these types

constructed was only 34.9 per cent of the total new mileage. The gravel type, which is the cheapest type capable of resisting moderate motor-vehicle traffic and the usual choice for the secondary improvement of earth roads, increased 48.2 per cent in net mileage, although in the new construction it constituted only 34.9 per cent. These differences between the new construction and net increases of the several types reflect the beneficial results of the stage construction.

Twenty-one Miles of Bridges Completed.—The 21.3 miles of bridges completed, while by no means comparable with the large completion during the preceding year, represent a very considerable addition to the list of important bridges constructed with Federal aid. Including the structures just completed the aggregate length of all completed bridges was 121.6 miles.

All of these structures are more than 20 ft. in span, and four completed during the year are longer than a mile. These bridges, which are among the longest in the country, are the interstate bridge over the Savannah River near Savannah, Ga., 1.6 miles in length; the bridge over the Missouri River near Lexington, Mo., 1.4 miles long; the bridge over the Raritan River at Perth Amboy, N. J., 1.6 miles long; and the Lake Champlain bridge near Milton, Vt., which is 1.2 miles in length.

Federal Aid Does Not Cause Extravagant State Expenditure.—The total cost of the 9,417.3 miles of original construction and the 1,193 miles of stage construction completed during the year was $206,139,220, of which $90,294,106 was paid by the Federal Government. These expenditures were made over the period required to bring the above mileage to completion, approximately two years, and during the same period additional expenditures were made upon other projects under construction.

The actual disbursement of Federal-aid funds was $87,754,534.57. This is a reduction of approximately $8,000,000 below the disbursement of the preceding year, and further reduction may be expected in the future as accumulated balances are expended and the program of expenditure reaches the rate set by the annual authorization of $75,000,000 of the recent past and immediate future.

As the annual highway expenditure of the country is in excess of a billion dollars, the Federal expenditure is not over 8 per cent of the total. And the fact that the percentage of interstate traffic on the roads of practically all States equals or exceeds that figure is evidence that, from the Federal point of view, the current rate of expenditure is not excessive, aside from all consideration of the general Federal and interstate benefits derived from the resulting improvements. But the Federal-aid road work is a co-operative undertaking on the part of the Federal and State Governments in which the States are required to match in certain proportions the expenditures of the Federal Government. It is proper, therefore, to inquire whether in thus matching the contributions of the government the States are induced to make expenditures for road improvement greater than they would make if the Federal aid were not offered.

That this is not the case is evidenced by the fact, that in 1925 every State, without exception, made expenditures for road improvement in addition to those made for the Federal-aid roads, the total of such expenditures being $438,544,000, or approximately four times the amount spent to match the Federal aid. These are State expenditures only. They do not include the amounts spent by the counties independent of State control which, doubtless, equaled or exceeded those of the States.

State Motor-Vehicle Revenues.—There is no ground for belief that the effort to meet the Federal contribution is burdensome to the taxpayers of the States. The State funds required to match a Federal appropriation of $75,000,000 a year in the proportions required by the Federal law amount to $67,081,920. As shown by Table IV the gross income of the States from motor-vehicle license fees and gasoline taxes amounted in the calendar year 1925 to $405,467,756, a sum sufficient to match the Federal aid six times over, almost large enough, indeed, to cover the entire annual expenditure of the State highway departments; and the amount of this income from the motor vehicle is still increasing with the phenomenal growth of registration. These special taxes are paid by owners of motor vehicles, not grudgingly, but with entire willingness so long as they are used for road improvement, because it is generally recognized that the return in the form of reduced operating expense and improved highway service more than compensate the tax.

Table IV.—Comparison of State Motor-Vehicle Revenues and Funds Required to Match Federal Appropriations

State	State funds required to match Federal appropriation of $75,000,000	Gross income from motor-vehicle license fees and gasoline taxes, calendar year 1925
Alabama	$1,541,870	$4,651,931
Arizona*	403,800	1,261,543
Arkansas	1,264,164	6,100,360
California*	1,628,000	22,773,087
Colorado*	1,068,000	3,391,245
Connecticut	474,801	7,553,056
Delaware	365,625	1,022,781
Florida	892,878	11,303,135
Georgia	1,983,089	7,429,239
Idaho*	628,000	2,088,030
Illinois†	3,191,479	12,969,754
Indiana	1,938,693	12,302,712
Iowa	2,070,396	13,246,218
Kansas	2,074,360	7,515,284
Kentucky	1,411,607	6,821,622
Louisiana	997,262	5,739,588
Maine	685,140	3,450,483
Maryland	635,783	4,553,337
Massachusetts†	1,090,118	9,843,901
Michigan	2,225,227	22,762,080
Minnesota	2,124,151	13,608,774
Mississippi	1,291,960	4,024,274
Missouri	2,417,727	11,426,213
Montana*	1,193,000	1,589,963
Nebraska	1,581,969	6,130,260
Nevada*	132,000	527,902
New Hampshire	365,625	2,443,166
New Jersey†	935,082	10,515,323
New Mexico*	690,000	995,230
New York†	3,657,096	25,506,245
North Carolina	1,699,168	14,442,222
North Dakota	1,180,699	1,717,989
Ohio	2,789,588	22,157,181
Oklahoma*	1,415,000	9,720,089
Oregon*	710,000	8,279,297
Pennsylvania	3,360,123	30,279,770
Rhode Island	365,625	2,182,312
South Carolina	1,052,549	6,231,479
South Dakota*	965,000	4,292,710
Tennessee	1,622,985	6,468,834
Texas	4,415,715	18,119,715
Utah*	229,000	1,618,239
Vermont	365,625	1,999,418
Virginia	1,449,713	8,002,901
Washington*	941,000	8,000,838
West Virginia	797,295	5,540,986
Wisconsin	1,873,308	11,927,886
Wyoming*	525,000	939,154
Hawaii‡	365,625	----------
Total	$67,081,920	$405,467,756

* States not on 50-50 basis on account of public lands and non-taxable Indian lands.
† No gasoline tax assessed.
‡ No tax data available.

As shown by the foregoing facts there is no reason to believe that the necessity of matching Federal aid has caused the States to incur a large bonded indebtedness. Twenty-four of the States have issued no bonds for highway purposes since Federal aid was initiated. The other 24 have incurred a total indebtedness of $604,410,600. In 13 of these the amount of the bonds issued has considerably exceeded the total of their Federal-aid apportionment, and cannot, therefore, have been required to match the Federal contributions. Of the remaining 11 States, 3—Massachusetts, New York and Rhode Island—are States of large resources, and it is not conceivable that they have needed to issue bonds to match the Federal aid. Two others—Louisiana and Nevada—have a negligible total indebtedness. The remaining 6 States are Colorado, Idaho, New Mexico, South Dakota, Utah, and Wyoming; and it is conceivable that their bond issues may have been necessary to provide funds with which to match the Federal aid offered to them; but their combined issues during the 10-year period amount to only $31,800,000, and they have received almost double that amount from the Federal Government.

$120,000,000 Bond Issue Discussed in Missouri.—The state legislature of Missouri has before it for consideration a proposal to float a $120,000,000 bond issue for road construction. Half of the issue would be used to complete the present state highway system of 7,640 miles, while the balance would go to the various counties and to the city of St. Louis on the basis of automobile registration, no county to receive less than $150,000. The proposal would be voted on at the next general election if approved by the legislature.

The Maintenance of Gravel Roads

Methods and Equipment Used in Certain Sections of Michigan Described in Paper Presented Feb. 17 at Highway Engineering Conference, University of Michigan

By J. T. SHARPENSTEEN

Maintenance Supervisor, Michigan State Highway Department

The conclusions which follow are based largely on the experience of maintaining more than 600 miles of state trunk line gravel roads in thirteen counties located in the northwestern part of the lower peninsula. It is not assumed that all the ways and means found effective on these roads may be applied with the same results in every locality, although it is believed that many of the methods used are applicable to gravel road maintenance in general.

Character of the Roads.—To fully appreciate the reasons for doing a number of things that have been done, it is desirable to understand the character of the roads being discussed. A large percentage of the mileage was improved as state reward roads with grades ranging in width from 16 to 24 ft. and gravel surfaces varying from 9 to 16 ft. in width. The narrow widths predominated and bank run gravel was used extensively in construction. A portion of the mileage was improved under state trunk line specifications but consists very largely of one-course construction. The balance of the mileage which appears to have been improved has been built up under maintenance by adding a small amount of gravel each year. A light, sandy soil is common to practically the entire territory. Gravel secured from local deposits, which is the main source of supply, has a sand filler and cannot be compacted so that it will withstand traffic and varying degrees of moisture.

On account of the gravel having a sand filler and the light sandy soil of which the roadbed was constructed, it was inevitable that the one would become mixed with the other, further reducing the possibility of maintaining a consolidated metal surface. To reduce the loss from loose gravel being thrown into the ditch, high shoulders were built and maintained. With loose gravel in dry weather there was some justification for high shoulders for retaining purposes, but in rainy weather the roads presented a canal-like appearance until the water had had time to soak into the roadbed, except in hilly sections water flowed down the inside line of the shoulders to low points, causing serious washouts. Under these conditions travel by automobile was slow, tiresome and expensive. Accidents were frequent and the loose gravel furnished a perfect "alibi" for every accident regardless of the cause.

In order to keep the investment in equipment as low as possible, it is necessary to secure equipment that can be used the year around. It is evident that certain equipment used in winter cannot be used in the summer. On the other hand, a major portion of the summer equipment, such as trucks and heavy tractors, can be used in snow removal work. There are special gravel road maintenance units that give satisfactory results when used for the purpose for which they are designed but for snow removal in this locality are of little or no use.

Effect of Winter.—Beginning with the spring break-up snow and ice are removed from the road as rapidly as possible. On roads which have been kept open for wheel traffic the ice covering disappears with the first few warm days of spring. On those roads not maintained for wheel traffic, during the winter a much longer time is required to clear away the snow and ice. On such roads, at points where there has been little or no drifting, the snow covering disappears in a short time, inviting automoble traffic to start using the road. By this time the drifts have settled down, making it possible to drive on top of them, resulting in the formation of ruts which soon wear down to the gravel surface. These ruts are filled with water and, with the concentration of traffic in them, soon extend deep into the gravel surface and, in many cases, into the subgrade, often rendering sections of the road impassable while the frost is leaving the ground. When the ice and snow have melted sufficiently to permit floating, the ruts have reached such depths that scarifying is really the only effective and sure way of removing them. On roads where snow removal is undertaken, floating can be started much earlier and the formation of ruts prevented. Snow removal is therefore an aid to summer maintenance and the added cost of putting a road, from which the snow has not been removed, in a satisfactory condition would go a long way toward keeping it open throughout the winter.

Early Spring Work.—For the purpose of early spring cutting a 10-ton tractor and a heavy grader are used. High shoulders are cut down so that water falling on the road may reach the side ditches without delay. The crown of the road is reduced to about ¼-in. to a foot width of road. The metal surface is spread out to a width of 20 ft. if posible. The outer edge of the widened metal surface is often quite thin but has been found of sufficient strength to give fairly satisfactory service in dry weather.

Floating with what might be called light equipment is started at the same time heavy cutting is begun. Trucks of 3 or 3½ tons capacity equipped with spring blade scraper attachments are used for the greater portion of this class of work.

Both 10 and 12-ft. spring blade attachments have been used and it was found that the 12-ft. length could be handled satisfactorily by a 3-ton truck and, in most cases, the entire width of gravel surface covered with one round trip. These attachments have been used in snow removal with very gratifying results. Light snows can be handled by this means alone and on trucks equipped with "V" plows the attachment can be used for cleaning at the same time heavy snow is removed by the "V" plow.

Eliminating Loose Gravel.—An effort was made during the past year to eliminate loose gravel. This was accomplished in a few instances by depositing it on the shoulders to remain there until late in the season. As a temporary expedient, this method was effective but has the same disadvantage as high shoulders and was used only as the last resort. The most satisfactory results were obtained from adding sufficient binder to consolidate all, or nearly all, of the loose material. Clay being the only local material having the desired binding qualities, it was used extensively. The application of binder was carried on by thirteen different organizations and, as might be expected, uniform results were not always obtained; however, with the exception of a few isolated cases, all loose material in the gravel surface was consolidated, ending a dangerous condition of long standing. Definite instructions for applying clay cannot be given on account of the clay in the different deposits not having the same characteristics and on account of no two miles of the same road requiring the same treatment. The success of the application depends very largely on the judgment of the man in immediate charge of the work. From ½ to 2 yd. per 100 ft. of road is the amount ordinarily used. It should be spread uniformly over the entire gravel surface and mixed with the loose material by harrowing or frequent floating. Following the first rain, intensive floating with both heavy and light equipment should be done until the surface has

dried sufficiently to prevent its being cut up by heavy loaded vehicles.

Results From Using Clay Binder.—A notable example of the results obtained by using clay is a 7-mile section on Trunk Line 13 located between Cadillac and Manton. In former years during dry weather, the surface of this road would become loosened to such an extent that the slag base would become mixed with the gravel in the surface course. Early last spring clay was applied at the rate of 1 cu. yd. to 100 ft. of road. Following the first rain the results were very unsatisfactory, but by floating constantly during the drying-up period, a smooth, uniformly shaped surface was obtained. After a few days exposure to the sun it was discovered that no material had been left for floating and the surface could not be cut with floating equipment. Immediately following succeeding rains a slight amount of material could be moved with a grader but, after it had dried up, floating was discontinued until the next rain. In the latter part of June calcium chloride was applied and following this the surface seemed to get even harder. Holes appeared occasionally on sharp curves, but these breaks were repaired by filling with clay and gravel to which a small amount of calcium chloride was added. The cost of patching for the entire season amounted to $75. The opinion was often expressed that this road could not be properly maintained in wet weather but it was a surprising fact that less trouble was experienced in rainy weather than on other roads that had not been similarly treated.

Resurfacing.—There has been a practice of doing as much resurfacing each year as funds would permit. This work was usually performed in the summer when traffic is heavier than at other seasons of the year and increased, instead of abated, the loose gravel menace. Light resurfacing, if done in the early spring or late in the fall, improves the road but it is believed that the same amount of money used in a different way will result in more satisfactory maintenance.

By stocking gravel at convenient points along the road and using it at places where there is an obvious need for additional gravel, a considerable saving can be made over a general resurfacing. All maintenance organizations are instructed to emphasize patching in rainy weather to the exclusion of all other work except possibly floating. All available trucks are loaded from stock piles and the gravel is placed wherever water is standing on the road. Roads dry up very quickly in the summer and, for this reason, it is imperative that the work of filling holes and low places be pushed as rapidly as possible. Frequently this work is performed while it is raining and, whenever possible, is done in advance of floating. Not all the necessary patching can be done in wet weather but, by doing as much as possible with each rain, the need for patching at other times is not of serious consequence.

Use of Dust Layer.—The use of a dust layer has been a very important factor in improving the condition of gravel roads. For this purpose calcium chloride only has been used. June 15 is the approximate date for making the first application in this section. A short time before making the first application, a heavy grader is used to reshape the road and, immediately preceding the application, all loose pebbles are scraped off and deposited on the shoulders to remain there during the life of the chloride. The first application is made at the rate of 4 or 5 tons to the mile, depending on the width of the metal surface. A distributor equipped with screens, baffle boards and having an agitator similar to a lime drill is used, and, although it may be considered of small importance, rubber tires on the wheels of the distributor make a substantial difference in the results obtained. Every effort is made to secure a uniform distribution which is very nearly impossible with steel tires. The distributor is attached to a heavy truck that is capable of maintaining a uniform rate of speed on rolling grades. A stake body is best for the truck to which the distributor is attached. One-ton trucks are used to haul from the car or storage and, by having a stake body on the heavy truck, the transfer of sacks from one to the other can be made rapidly. The practice of changing the distributor from one truck to another is discouraged. No floating is done until the chloride is completely dissolved, which is usually the next day following the application. The cost of applying chloride in this way costs, on an average, about $1.60 a ton with a low figure of $1.23 a ton in one country. The cost, of course, depends on the length of haul The same methods are used in making subsequent applications as in making the first. In case eight tons to the mile are specified, the second application of three tons is made just before Labor Day. It has been found that the length of time which chloride lasts can be increased very materially by the use of clay as a binder.

Distribution of Traffic.—To secure an absolutely uniform distribution of traffic over the entire width of the metal surface is probably impossible, but the basic idea kept in mind at all times is to approach this condition as near as possible. The attainment of this end involves a low crown and a surface in such condition that the driver of a motor vehicle cannot, consciously or unconsciously, follow in the tracks of vehicles that have preceded him.

An operator of a motor vehicle experiences difficulty in driving over a loose gravel road that has just been floated. Succeeding drivers find less difficulty because they followed in the tracks already made by preceding vehicles. This means a high concentration of traffic on from 10 to 15 per cent of the metal width. The degree of concentration varies directly with the depth of loose material present.

An estimate of the wear of gravel must take into consideration the amount of loose cover used for maintenance. It is self-evident that the loss from the erosive action of wind and rain, the abrasive and throwing action of traffic, the air currents created by rapidly moving vehicles, varies directly with the quantity of loose material acted upon by these forces. Therefore, in order to reduce wear to a minimum, it is necessary to reduce cover material accordingly.

The Final Test.—The final test for gravel road maintenance is the class of service furnished the traveling public. The amount of money required to furnish good maintenance depends on the class and quantity of traffic accommodated. With modest allowances every effort has been made to economize and yet, at the same time, there has been a constant public demand for better maintenance. To get by, so to speak, the employment of methods, that in some instances conflict with well-established usage, has been made necessary. Improvement is often the result of abandoning ideas that have served useful purposes and it is believed that the ultimate solution for gravel road maintenance will be found in keeping the surface in such condition that floating or scraping can be dispensed with except in wet weather.

Highway Traffic in New Hampshire.—The Trunk line highway system of New Hampshire consists of about 775 miles of gravel road with surface treatment, 126 miles of plain gravel, 87 miles waterbound macadam, 138 miles bituminous macadam, 67 miles modified asphalt and 16 miles of concrete. A transportation survey made last summer by the U. S. Bureau of Public Roads showed that on 171 miles of the trunk line system there was a daily traffic of from 1,500 to 6,000 vehicles per day; on 853 miles there was a daily traffic of from 500 to 1,499 or 1,500 vehicles per day and on 423 miles up to 500 per day.

Missouri May Have $100,000,000 Road Bond Issue.—A second road bond issue of not less than $100,000,00 is practically certain to be submitted to the Missouri legislature. Only about $5,000,000 of the original $60,000,000 bond issue voted in 1920 remains to be contracted for. The primary system of the state comprises a total of 7,640 miles. Approximately one-half of this system has had some type of improvement during the four years that work has been in progress. One federal highway, U. S. 40, the main cross-state road between St. Louis and Kansas City, has been completed.

Economy of Snow Removal

Advantages of Keeping the Roads Open Discussed at Convention of American Association of State Highway Officials

By W. A. VAN DUZER
State Highway Department of Pennsylvania

Maintaining traffic during the winter months is becoming one of the most important functions of a maintenance organization.

The organization of snow removal forces is very similar throughout the country; the starting of the men, actually removing the snow, the supervisor in charge, the district supervisor in charge of county or other unit, and finally the headquarters' directing head, to whom conditions are reported so that information can be given to the newspapers and the traveling public.

Equipment, by this I mean plows, trucks, tractors and snow fence, must be balanced. From past experience with drifting conditions, it is possible for the local supervisors to designate sections where snow fence would be required, and under normal conditions trucks with "V" and moldboard types will expeditiously remove the snow.

Drift prevention adds materially to the reduction in cost of snow removal work, but it is necessary, in order to meet emergencies, to have large equipment such as tractors equipped with either "V" type or rotary type plows, available for transfer to points where a shifting wind has caused drifting or where lack of sufficient snow fence has caused a depth of snow that can not be removed by the ordinary truck plow.

From the highway engineers' standpoint, snow removal is the means of avoiding partial loss of the investment value in road improvements and of reducing maintenance costs.

If a road is blocked, the investment is idle and the interest value is being lost. If snow drifts are allowed to remain on the road, when traffic does break through it will follow the line of least resistance and will travel in ruts, weaving from side to side and out on the shoulders at intervals; when the snow melts the shoulders will suffer, and if the pavement is a flexible type, it will be seriously damaged.

The Pennsylvania primary system represents an investment of about $150,000,000, which at 5 percent is worth $625,000 per month, or if service is considered, winter traffic being approximately one-half of the annual average, it is worth $312,500 for a winter month. Unremoved snow would block the roads about two months with a loss of $625,000 of interest value alone. I believe snow removal saves us at least that much, additionally, in reducing repairs and depreciation. Snow removal in Pennsylvania costs about one-half as much as we believe it is worth.

The traveling public's interest in snow removal is to be considered. Just as there must be a constant relation between production and consumption, so there must be an equal balance between providing transportation facilities and their use, and the value of the roads to the traveling public should at least equal the physical valuation.

Approximately one-half of all the car miles of travel in the State of Pennsylvania are on our primary system. Therefore the blockade of the primary system would mean a 50 percent loss of interest value in the motor vehicles registered in the State. The total number registered is approximately a million and a half, representing something like one billion dollars of investment and five million dollars interest value per month. Two and one-half million dollars then would be the total interest value for a winter month and one and one-fourth million dollars the interest value to set against a month's use of the primary system in winter.

We would need to show only one and one-fourth million dollars snow removal value to the traveling public, on the basis of two months' blockade, to check the estimate of corresponding value to the State, and the fact that the value to the traveling public is shown to be double the value to the State may be an explanation of the fact that we are urged to increase the snow removal program each year.

Viewing the work of snow removal from the standpoint of economy, there is no doubt that in many cases drift prevention is more economical than snow removal. In a number of cases we have actually been able to eliminate bad winter conditions by relocating sections of road and placing them on wind-swept ridges instead of on side hills. In other cases, we have been able to improve conditions by raising the grade line, widening the cuts, and flaring their entrances.

In cases where we were unable to eliminate the objectionable drifting tendencies by relocation or grading, we found that we save money by the use of snow fence.

The most economical type of snow fence appears to be a woven picket and wire hung on driven steel posts. This fence is easily removed, and the cost is about one-third of the railroad type of snow fence.

Passing on to equipment, the requirement of economy is accompanied by the proviso that the equipment must be able to handle the work. We find that in general our ordinary tractor and truck equipment, fitted with adjustable plows, will keep our roads open, but in sections where we have the heaviest snow fall a more powerful type is required and used even though its cost is greater. The justification for the greater expenditure is that the roads in this section can not be kept open continuously except with special equipment.

There is little opportunity for discussion of organization from the standpoint of economy, the advisability of handling the work with the general maintenance organization being so obvious.

We believe that all States that have heavy snow fall and that are doing snow removal work find that providing winter employment for their best maintenance men has simplified their problem of spring reorganization of working forces.

Clearing the pavement its full width does not constitute all of snow removal work. It is necessary to spend more money after clearing the pavement in order to save money when the next storm comes. Snow banks must be moved back to make room for the disposal of additional snow, shoulder drains must be opened at intervals along the road, as well as culverts and side drains, especially when thawing weather comes, to secure the full value of snow removal in reducing spring maintenance costs.

As an added service to the traveling public, it has been the practice for several years in Pennsylvania to place cinders or screenings upon certain sections of pavement that are icy. The cost is very small and it not only receives favorable comment but, from personal experience in driving over these roads, we know that this method has prevented numerous accidents.

Qualification Requirements for Bidders on Iowa Road Work

The Iowa State Highway Commission has set up new qualification requirements for bidders on highway work in that state. The new provision in the specifications follows:

"Any person, firm or corporation, desiring to submit a proposal on this work who has not heretofore constructed paving on the primary road system of this state under the State Highway Commission's supervision, shall, at least five days before the date of receiving bids on this work, file with the commission, on forms prepared by the commission, a statement of said bidder's financial standing, equipment and experience on similar work. The commission will examine said statement and will, prior to the time for filing bids on work, advise said bidder of the number of miles of paving, if any, for which the commission would be willing to award or approve a contract for said bidder in case the bid should be low. In no event will a contract be approved with or awarded to such bidder for more than about 10 miles of paving.

"Any prospective bidder who has not substantially completed his first contract shall file the above mentioned statement as above provided, with the commission who will examine the same and advise the bidder prior to the time of filing bids, how many miles of paving, if any, for which the commission would be willing to approve or award a contract."

Over 4,000 Motor Vehicles Owned by New York City.—The City of New York now maintains a motor fleet numbering over 4,000 pieces. This represents an increase of 3,500 pieces, not including motorcycles, in the last 10 years.

Grade Separation in Michigan

What Is Being Done to Eliminate Dangers of Railroad Crossings Described in Radio Talk

By C. A. MELICK
Bridge Engineer, Michigan State Highway Department

The menace of the grade crossing, as affecting the safety of life and property, is increasing with the rapidly changing traffic conditions on our highways. The volume of traffic, as gauged by motor vehicle registrations, has doubled in the last 5-year period, from 1921 to 1926. The rate of production of cars and the rate of vehicle registration has likewise been increasing during this five year period and is still showing an increase and it is not unlikely that the present traffic volume will again be doubled within the next ten years.

The Increase in Speed.—We have witnessed the increase in speed permitted by our various state statutes from an initial of from 20 to 25 miles per hour, first to 30 then to 35 miles per hour and in one state today this limit is set at 45 miles per hour. It is very commonly conceded that all speed limitation, except as it may be combined with other conditions in such manner as to classify as careless driving, may soon be removed from the statutes uniformly throughout the United States.

The use of heavy motorized fast moving carriers of freight, express, merchandise and passengers is steadily increasing and the proportion of such vehicles to the total registration is likewise steadily increasing.

The railroads today are experimenting with improved roadbeds which will make safe at all seasons higher speeds and heavier loads. On the other hand, increasing reliability of motor vehicle mechanism and brakes on both motor vehicle and railroad equipment together with a general tendency to increase the safety precautions and traffic regulations tend somewhat to offset the other factors enumerated as multiplying the dangers of an already very dangerous crossing situation. Railroads today concede the danger of derailment of an entire train through a motor vehicle collision and are ready to assist in grade separation within the reasonable limitation of their resources.

The safety of railroad crossings is best promoted by complete elimination. Often by merely interchanging the rights of way together with a short stretch of reconstruction, it is possible to completely and safely eliminate a pair of crossings. Obviously this remedy can only apply to crossings where the highway and railway in general have parallel routes. Michigan trunk highways contain many examples of this type which are rapidly being done away with.

Methods of Improving Safety of Crossings.—When the railway and highway have termini so located that the routes must cross, the safety of the crossing may be improved by a combination of one or more of the following four methods:

First, By clearing the area adjacent to the tracks and highway within a reasonable distance of the crossing of all natural and artificial features affecting clear vision, including brush, trees, fences, signs, buildings, and cultivated crops.

Second, By local changes in the highway approaches to the crossing to insure straight approach alignments with gradients preferably on a very slight rise approaching the tracks, thereby facilitating the stopping of motor vehicles and insuring a view of the crossing warnings for a distance of not less than 300 feet of straight away either side of the crossing.

Third, By installation of warnings which can not be overlooked by the motorist in approaching the crossing, these safety provisions warning of the existence and exact location of the crossing and of the railroad tracks either side approaching the crossing. An overhead archway extending entirely over the highway at each right of way line, illuminated by a flood light and painted in black and white relief with large exposed surfaces and of a height just sufficient to pass the maximum equipment using the highway, together with a practice of painting the telegraph poles along the railroad on either side of the crossing a plain white for a distance of 1,000 feet each way would give ample notice of the existence and location of both the crossing and the adjacent track.

Use of Flashing Signals.—Fourth, By the installation of a red flashing signal to warn of the immediate presence of railroad traffic, the flash being provided with a track circuit of sufficient length to permit the fastest train to stop within the block before hitting the crossing should a vehicle be seen at the crossing within the right of way limits when the flash first begins to operate. This flash should be placed at the right hand side of the road with the beam directed across the path of approaching highway traffic at about a 10 degree angle and at a height of about 8 feet above the road so as not to be obscured by pedestrian or motor traffic. A great stride has been made in the last few years in the development and use of the flashing light system, the present practice for protective measures relying almost wholly upon this device. It is difficult to predict how far a proper combination of all four of the above relief measures would go toward postponing or in many cases possibly making unnecessary the expensive project of separating the grades at least within a period of say 10 years, which might be considered as the reasonable length over which a grade separation program should be distributed. Grade separation is, however, the only positive cure for the menace to life and property at these grade crossings and within the reasonable limits of our financial resources all crossings should be either eliminated or separated, protective devices and improvements being considered only as a temporary measure pending the provision of funds for separation.

Safety, however, is not the only consideration which requires the separation of the grades at these crossings. There are many crossings in the state where the railroads usurp over 6 hours of the 24 hours per day for switching and sorting freight cars to yards and to warehouse and factory sidings over important highway crossings. The railroads work to their legal right to block these crossings at will for the full legal 5-minute periods with as many periods of this length as they desire. A proper use of the highway would seem to require that these crossings be separated.

Cost of Protection of Crossings.—We will now consider the cost of protection and of separation at these crossings and the ability of the state and of the railroads to finance a protective program of reasonable breadth to be carried out within a reasonable period of time. On Aug. 1, 1925, we had in this state on our trunk line highways 582 grade crossings with steam and electric railroads. About 135 crossings had up to this time been eliminated by means of relocation in connection with the highway improvement projects. It is possible that a like additional number may in the future be similarly eliminated by relocation, leaving about 447 crossings to be considered for protective measures or for grade separations. We may consider that our average grade separation project will cost about $80,000.00. In view of the rapid increase in highway traffic, it is believed that a ten-year period is about the maximum time which should be allotted for a separation or improvement program.

If we assume that within this ten year interval complete separation of the grades is necessary for each of the 447 crossings, a total sum of $35,760,000 would be required and assuming that the state and the railroad companies would bear this cost equally would require a total expenditure of $17,880,000 on the part of each or an annual expenditure on the part of each of $1,788,000. This sum seems quite trivial when we consider that the state of New York has recently authorized an expenditure of $300,000,000 on the part of the state alone to finance a ten year separation program. The state of Maryland has likewise recently entered into a compact with the railroads in that state for jointly separating all trunk line crossings within a ten year period.

To protect a crossing with the third type of protection, previously referred to, would cost about $650.00 per cross-

ing. The fourth type of protection, using electric circuits, costs ordinarily about $1,700 per crossing with an annual maintenance and operating charge of about $200. Standardization of equipment and methods might possibly reduce the cost of the fourth type of protection to $500. Protection of the first two types referred to will vary considerably and in built up commercial districts the improvement is often prohibitive in cost. We could probably assume that 100 of these 447 crossings could be left of the protected type for a ten year period at an average cost of not over $2,000 each, or a total of $200,000, which is a small program and might be conveniently carried out in any single year. This would reduce the separation program to a total of 347 crossing at a total cost of $27,760,000, entailing an annual expenditure for state and railroads of $1,388,000 for each.

It is probably safe to assume that about two-thirds of all these grade crossings will be situated on the three railroads known as the Michigan Central, the Pere Marquette and the Grand Trunk. In 1926, these railroads paid into the State Treasury in the form of corporation taxes $2,480,000, $1,067,000, and $434,000 respectively, these sums being in each case practically double the corresponding amounts paid in 1918. Under the present law no part of this tax is apparently applied to safeguarding the public from the dangers attendant upon the operation of these railroads. Assuming that each of these three companies be considered as paying an average tax of $1,327,000, each railroad would have to contribute to the grade separation cause $312,000 or 23½ per cent of the present annual tax now devoted to school purposes. This does not appear to be an unreasonable or impractical amount. The state's share must obviously be derived from the highway revenues. The gas tax for 1927 has been estimated $10,500,000 with a corresponding weight tax estimated at $16,500,000 or a total of $27,000,000 which is disposed of for various highway purposes. The annual sum required for the grade separation program above outlined would require only five per cent of this sum to guarantee the completion of the program in a ten year period and it is well to note that these estimates entirely neglect the assured increase both in highway revenues and in the corporation tax of the railroads which would naturally rise from increased valuation during the ten year interval of improvements.

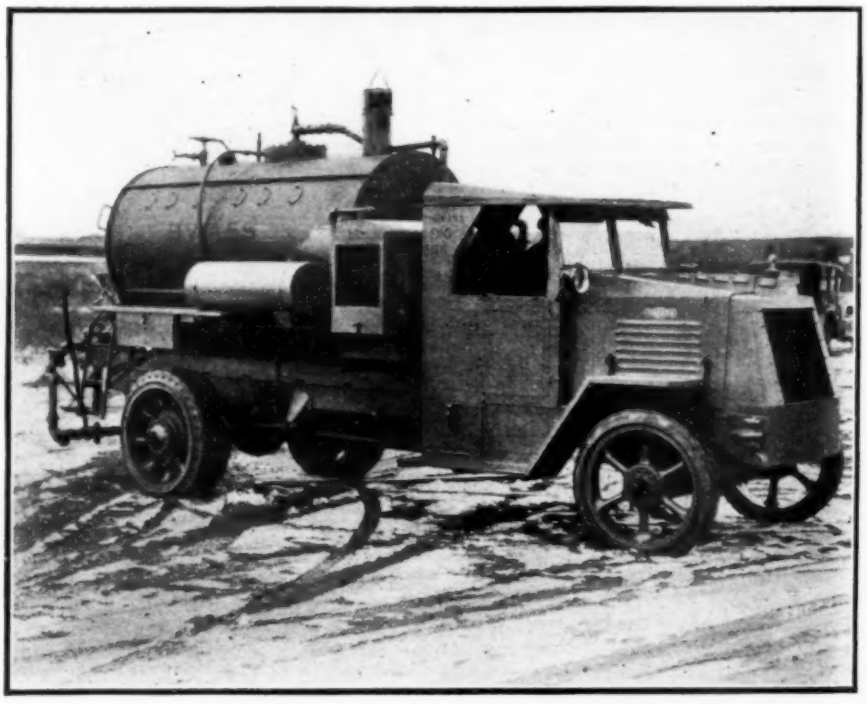
57 Grade Separations Already Built.—At the present time there are 57 grade separations on our trunk line roads which were built by the railroads alone or in co-operation with the townships and counties without state aid. Up to October 1, 1926, the state had built or placed under contract only 24 grade separations, which were distributed among the various railroads as follows: Michigan Central, 5; Pere Marquette, 9; Grand Trunk, 4; others, 6. It will be noted that exactly two-thirds of these separations were accounted for by the three railroads previously cited.

There are at the present time under consideration 32 projects of which the following are allotted to the three railroads noted: Michigan Central, 7; Pere Marquette, 4; Grand Trunk, 5, a total of 16 which constitutes 50 per cent of the tentative program. This is considered as below what would normally be anticipated. The annual program on a ten year basis with 347 separations considered would mean the placing under contract of 35 grade separation projects per year which would require very caeful planning. Standadization and uniformity of requirements on the part of the railroads and state and additional legislation would be necessary as there are hardly any two railroads in this state which will agree to the same provisions for clearance heights and widths and types of structures at the present time.

In considering the matter of grade separation on our trunk line highways, we must, in closing, not fail to make proper allowance for the increase in the number of separations necessitated by the selection of entirely new highways or by additions to our trunk line mileage which will be required for the increasing volume of traffic. It is evident that we are now entering a period of rapidly increasing activity in the elimination and grade separation of railroad crossings on our busy highways.

New 5-Ton Truck

The Indiana Truck Corporation, Marion, Ind., has brought out a new 5-ton truck, known as Big Steve Model 41. The engine has four cylinders, 4¾-in. bore, 5¾-in. stroke. L-head; cylinders and crankcase cast in block, detachable cylinder head, high compression type. Lower pan is pressed steel, used as oil reservoir only. Valves on right side, all working parts enclosed. Valve diameter 2¼ in. Three point suspension. Crankshaft bearings 3 in. diameter. Length of front 3¼ in., center 3¼ in., rear 3½ in. Connecting rod bearings 2½ in. in diameter and 2⅝ in. long. Piston pin bearing 1½x 3¼ in. Oiling is by full force system to main and connecting rod bearings and timing gears. Gear pump submerged in oil reservoir delivers oil at 15 lb. per square inch. Oil filtrator prevents foreign substance from reaching bearings. Water circulation is by centrifugal pump. Governor operated from oil pump shaft. Set and sealed at factory. Combination air cleaner and stove mounted on top of engine.



Indiana Big Steve Truck Equipped with Tarvia and Oil Distributors

The frame is of special process heat treated, pressed steel channel of 3½ per cent chrome nickel steel, 8 in. deep, 3 in. flange, ⅞ in. stock. Does not require truss rods or reinforcements. All castings are hot riveted to frame. The frame dimensions are: Length back of seat 156 in. standard, 180 in. long, 109½ in. short. Length from seat to center of rear axle 98¼ in. standard, 122¼ in. long, 74¼ in. short. Width of frame 36 in. The turning radius is 34 ft. The gear ratio is: Standard 10 to 1, giving a speed of 18½ miles per hour in direct and 23.7 miles in overspeed.

How Albany Regulates Traffic

An Interesting Solution for a Very Difficult Traffic Problem Effected on the asis of a Thorough Survey and Study

Albany, New York, like many other American cities, was laid out long before modern traffic conditions, and even modern population, could even be hinted at. Today, with a population of about 119,000, it has so outgrown its business center that the problem of controlling traffic therein has become a matter of concern. Not only is Albany the capital of the state, but it marks the convergence of several important tourist routes. The foreign traffic, alone, adds greatly to the seriousness of the problem.

The Mayors' Conference.—Early in 1925, a conference of mayors of cities in New York State was held to discuss the traffic problems of the state in an orderly manner. It was there proposed that a demonstration be held in some city of the state to determine the best traffic control measures, traffic facilities, devices and methods of law enforcement to afford safety to vehicular and pedestrian traffic in municipalities, to carry on the work and announced that its recommendations would be put into effect and given a fair trial. Aid in the work was rendered by the Metropolitan Life Insurance Company, which supplied the services of its safety engineers.

Careful Study Made.—After making a careful study of traffic movements, of the location, and causes of accidents, and of other factors affecting the situation, the Mayor's Traffic Commission presented a report recommending a plan for one-way streets, suggested

STATE OF NEW YORK
BUREAU OF MOTOR VEHICLES

REPORT OF AUTOMOBILE ACCIDENTS IN City of Albany — DURING THE MONTH OF Jan - Dec (incl) 1925

1. SUMMARY OF ACCIDENTS BY TYPE OF ACCIDENT AND AGE OF PERSONS KILLED OR INJURED

TYPE OF ACCIDENT	Number of Accidents	Number of Persons Killed: All Ages	0-4	5-14	15-24	65 and Over	Not stated	Number of Persons Injured: All Ages	0-4	5-14	15-24	65 and Over	Not stated
0. Collision with pedestrian	435	7	1	2	2	2		441	26	157	152	52	54
1. Collision with automobile	136	2			1		1	223	6	10	169	15	23
2. Collision with horse-drawn vehicle	11							12		1	7	2	2
3. Collision with R. R. train													
4. Collision with street car	13							20		1	14	2	3
5. Collision with other vehicle	38							45		7	35		3
6. Collision with fixed object	15	1			1			19			18	1	
7. Non-collision accident	4	1			1			7			6		1
8. Miscellaneous	5							7	1	1	1	1	3
9. Not stated	2							4			4		
Grand Total	679	11	1	2	5	2	1	778	33	177	406	73	80

2. HOUR OF OCCURRENCE	Number of Accidents: Total	Fatal	Non-fatal
2 to 1 A. M.	13	2	11
1 to 6 A. M.	32		32
6 to 7 A. M.	2		2
7 to 8 A. M.	17		17
8 to 9 A. M.	28		28
9 to 10 A. M.	17		17
10 to 11 A. M.	23		23
11 to 12 A. M.	37		37
12 to 1 P. M.	32		32
1 to 2 P. M.	41	1	40
2 to 3 P. M.	43	1	42
3 to 4 P. M.	35		35
4 to 5 P. M.	58	2	56
5 to 6 P. M.	48		48
6 to 7 P. M.	62	2	60
7 to 8 P. M.	59	2	57
8 to 9 P. M.	43		43
9 to 10 P. M.	42		42
10 to 11 P. M.	31		31
11 to 12 P. M.	15	1	14
Not stated	1		1
Totals	679	11	668

3. DAY OF OCCURRENCE			
1. Sunday	80	2	78
2. Monday	101	2	99
3. Tuesday	86	1	85
4. Wednesday	113	1	112
5. Thursday	97	1	96
6. Friday	93	1	92
7. Saturday	109	3	106
8. Not stated			
Totals	679	11	668

4. NATURE OF INJURIES	Number of Persons Injured
0. Fractured skull	1
1. Fractured spine	
2. Other fractures	37
3. Concussion of the brain	
4. Severe general shock with contusions and lacerations	68
5. Slight shock and shakeup	608
6. Internal injuries	4
7. Other injuries	15
8. Not stated	45
Total	778

5. DESCRIPTION OF DRIVERS INVOLVED IN AUTOMOBILE ACCIDENTS	Number of Drivers: Total	In Fatal Accidents	In Non-fatal Accidents
Driver's sex			
Male	817	13	804
Female	36		36
Driver's age			
Under 16 years	5		5
16 to 24 years	251	4	247
25 to 64 years	491	8	483
65 and over	27		27
Not stated	70	1	78
Driving experience			
0. Less than 3 months	22		22
1. 3 to 6 months	14	1	13
2. 6 to 12 months	27		27
3. 1 to 2 years	77		77
4. 2 years or more	592	9	583
5. Not stated	121	3	118
Total number of drivers	853	13	840

7. RAILROAD CROSSING ACCIDENTS	Number of Accidents at Railroad Crossings: Total	Fatal	Non-fatal
0. Gates not down			
1. Guarded crossing			
2. Unguarded crossing			
3. Car run through crossing gates			
4. Driver disregarded signal			
5. Not stated			

6. THE MOTORIST	Number of Motorists Involved: Total	In Fatal Accidents	In Non-fatal Accidents
00. Driving properly	211	1	210
01. Skidding	20		20
02. Exceeding speed limit	38	2	36
03. On wrong side of road	19		19
04. Did not have right of way	70	1	69
05. Cutting in	11		11
06. Passing standing street car	6	1	5
07. Passing on curve or hill	3		3
08. Passing on wrong side	3		3
09. Failed to signal	25		25
10. Backing	14		14
11. Cutting left corner sharply	14		14
12. Car ran away	5	1	4
13. Car ran off roadway	10		10
14. Car passed through safety zone			
15. Car parked or standing still	22		22
16. Driver had physical defect	1		1
17. Driver was intoxicated	4		4
18. Driver was inattentive	365	7	358
19. Miscellaneous	1		1
20. Not stated	11		11
Totals	853	13	840

8. CONDITION OF VEHICLES INVOLVED IN ACCIDENTS	Number of Vehicles Involved: Total	In Fatal Accidents	In Non-fatal Accidents
0. In apparent good condition	512	4	508
1. Brakes defective	6		6
2. Steering mechanism defective	5		5
3. Glaring headlights	2		2
4. One or both headlights out	2		2
5. Tail-light out or obscured	4		4
6. No chain (wet and slippery road)	10		10
7. Other defects in equipment	3		3
8. Not stated	300	9	300
Totals	853	13	840

10. THE PEDESTRIAN (Accidents involving pedestrian)	Number of Accidents Involving Pedestrian: Total	Fatal	Non-fatal
00. Waiting for, or getting on or off street car in safety zone	4		4
01. —— Same; no safety zone	11		11
02. Getting on or off other vehicle	8		8
03. Crossing at intersection—with signal	2		2
04. —— Same; against signal	4		4
05. —— Same; no signal	95	2	93
06. Crossing, not at intersection	76		76
07. Standing on safety zone			
08. Walking, running or playing in str't	185	4	181
09. At work in roadway	11	1	10
10. Riding or blinding on vehicle	5		5
11. Not on roadway	15		15
12. Not known			
13. Was intoxicated	6		6
14. Had physical defect	2		2
15. Was confused by traffic	4		4
16. View obstructed	10		10
17. Miscellaneous	1		1
18. Not stated	2		2
Totals	441	7	434

9. TYPES OF VEHICLES INVOLVED IN ACCIDENT			
0. Passenger car	608	9	599
1. Commercial car	145	2	143
2. Taxi	57	1	56
3. Omnibus	5	1	4
4. Motor cycle	24		24
5. All others	1		1
6. Not stated	13		13
Totals	853	13	840

11. ROAD CONDITIONS	Number of Accidents: Total	Fatal	Non-fatal
0. Defect in roadway	14		14
1. Road under repair	1		1
2. Obstruction not lighted			
3. Straight, level road	311	7	304
4. Curve	8		8
5. Street intersection	329	4	325
6. Miscellaneous			
7. Not stated	16		16
Totals	679	11	668

12. ROAD SURFACE			
0. Icy surface	506	7	499
1. Wet surface	125	3	122
2. Muddy surface	4		4
3. Snowy surface	11		11
4. Icy surface	16	1	15
5. Not stated	17		17
Totals	679	11	668

13. WEATHER CONDITIONS			
0. Clear	518	9	509
1. Cloudy	43		43
2. Fog	2		2
3. Rain	88	2	86
4. Snow	5		5
5. Not stated	23		23
Totals	679	11	668

14. LIGHT CONDITIONS			
0. Day light	424	4	420
1. Dusk	45		45
2. Artificial light — good	28	1	29
3. Artificial light — poor	6		6
4. Darkness	166	6	160
5. Not stated	10		10
Totals	679	11	668

Fig. 1—A tabulation of automobile accidents occurring in Albany in 1925. Such a chart is a necessary part of a traffic control plan.

Poor Street Layout.—The city is further embarrased by the fact that it is located on very hilly ground and that the prineipal thoroughfares follow converging lines, culminating in a very difficult system of intersecting narrow streets in the most congested center of the city.

It is but to be expected that the confusion that resulted from the attempt to regulate modern traffic by means of policemen at the intersections lead to a high accident rate. Outgrown parking regulations reduced traffic movement materially. In short, a very undesirable condition had come into being, and some solution had to be found.

The plan was endorsed by the State Commissioner of Health, the Director of the State Motor Vehicle Bureau, the Superintendent of the State Police, and by other authorities.

Since the Conference desired to apply the test where the greatest good could result, Albany was selected as the subject of the investigation. The mayor of that city, the late William S. Hackett, then appointed a traffic commission and to discover how great a reduction of accidents could be made by an application of such measures in some city of the state.

parking regulations, widening of streets, marking streets and posting regulations, routing through traffic and posting routes, boulevard-stop streets and their regulation, posting boulevard stops, automatic traffic signals—type, location and timing, regulation of bus stops, regulation of pedestrian traffic, plan for court procedure in traffic cases, handling of traffic violations by police, police traffic school, permanent municipal traffic bureau, and a continuous city-wide safety campaign.

An Engineering Problem.—The commission realized that the traffic prob-

lem was an engineering problem, and that recommendations for its solution would have to be based upon accurate facts and sound engineering principles. Trained engineers were therefore put to work to make the necessary accurate studies, while additional facts were brought out through public hearings, cooperation with merchants, and the aid of the press.

Scope of Study.—The scope of the study made by the Traffic Commission in indicated by the titles of the ten thus advising the public of the progress of the work.

Analysis of Street Accidents.—Since any orderly system of traffic regulation must be partly based upon statistics of accidents occurring within the boundaries to be considered, the work in Albany began with an extensive study of that situation. Statistics for the year 1925 were obtained from the New York State Bureau of Motor Vehicles for study. This investigation revealed many interesting facts. During the year, 679 automobile accidents were reported to the police, in the city of Albany; and these resulted in the death of 11 persons and the injury of 788 persons. Four hundred thirty-five or 64 per cent of these accidents involved pedestrians, of whom 7 were killed and 441 injured. Briefly, 63 per cent of those killed and 56 per cent of those injured were pedestrians. Collision of automobiles accounted for 156 accidents, or 23 per cent of the total. These accidents caused the injury of 223, or 29 per cent, and the death of 2, or 18 per cent. There were 49 collisions of automobiles with other vehicles, 15 collisions with a fixed object, 13 collisions with street cars, and 11 miscellaneous accidents.

When Accidents Occur.—Of the 679 accidents occurring in the city, 311, or 46 per cent, happened on straight, level streets or roads between intersections. Dry streets lead to 506, or 75 per cent of the accidents. Five hundred eighteen or 76 per cent, occurred during clear weather, and 424, or 62 per cent, in daylight. In other words, an average of about 65 per cent of all of the accidents happened under the most favorable of driving conditions. This suggested that by far the largest percentage of accidents could only be prevented by the use of greater care on the part of the driving public and of pedestrians.

Other Accident Data.—A far smaller proportion of accidents than might be expected were due to defective equipment of automobiles. Only 32, or 3.7 per cent could be assigned to such causes as defective brakes, defective steering mechanism, glaring headlights, obscured lights, lack of chains, and so on. Of the 853 motorists involved in

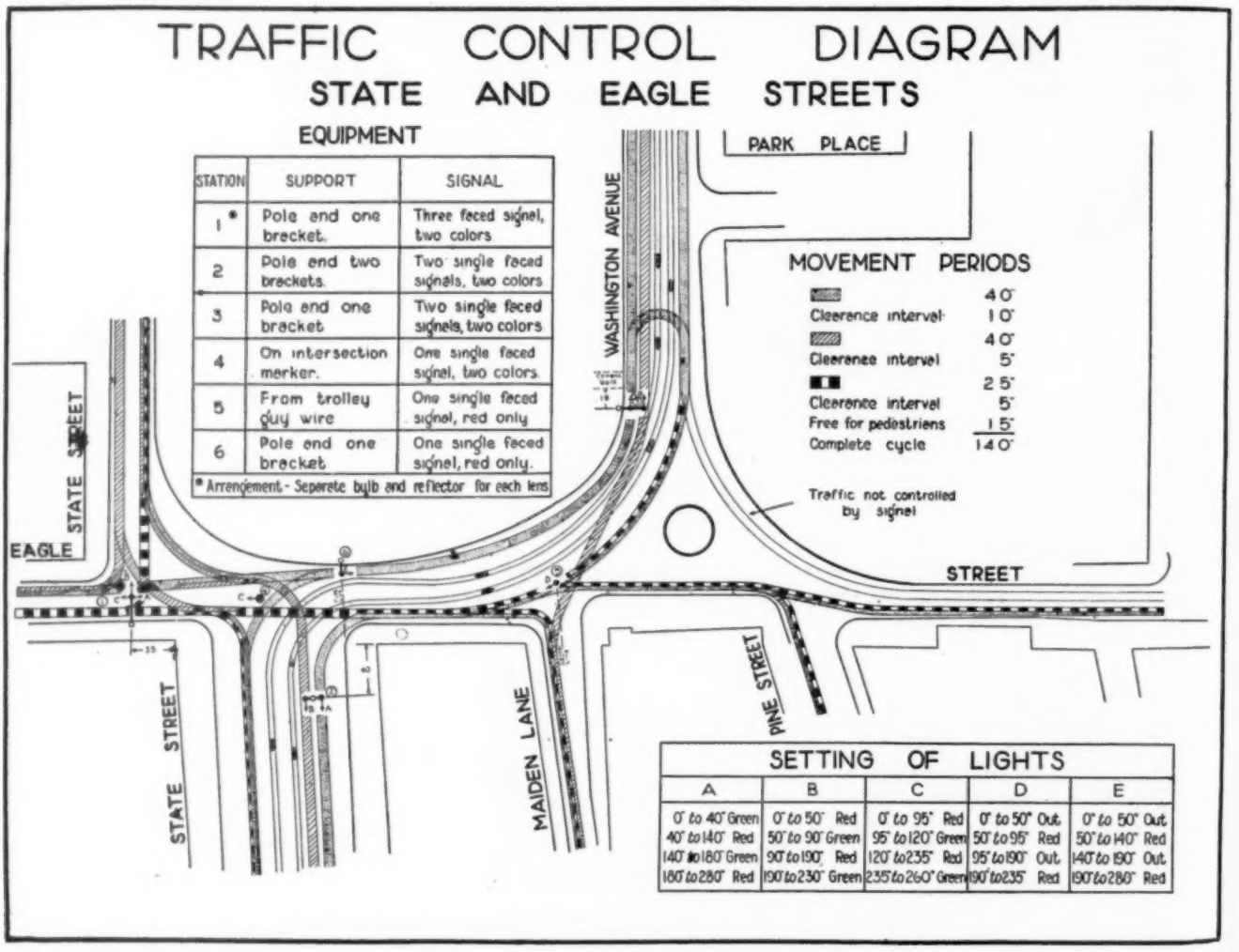

TRAFFIC CONTROL DIAGRAM
STATE AND EAGLE STREETS
EQUIPMENT
STATION | SUPPORT | SIGNAL
1 * | Pole end one bracket. | Three faced signal, two colors
2 | Pole end two brackets. | Two single faced signals, two colors
3 | Pole end one bracket | Two single faced signals, two colors
4 | On intersection marker. | One single faced signal, two colors.
5 | From trolley guy wire | One single faced signal, red only
6 | Pole end one bracket | One single faced signal, red only.
* Arrengement - Seperate bulb and reflector for each lens
PARK PLACE
WASHINGTON AVENUE
MOVEMENT PERIODS
40"
Clearence interval 10"
40"
Clearence interval 5"
25"
Clearence interval 5"
Free for pedestriens 15"
Complete cycle 140"
Traffic not controlled by signel
EAGLE STREET
STATE STREET
MAIDEN LANE
PINE STREET
STREET
SETTING OF LIGHTS
A | B | C | D | E
0° to 40° Green | 0° to 50° Red | 0° to 95° Red | 0° to 50° Out | 0° to 50° Out
40° to 140° Red | 50° to 90° Green | 95° to 120° Green | 50° to 95° Red | 50° to 140° Red
140° to 180° Green | 90° to 190° Red | 120° to 235° Red | 95° to 190° Out | 140° to 190° Out
180° to 280° Red | 190° to 230° Green | 235° to 260° Green | 190° to 235° Red | 190° to 280° Red

Fig. 2—Here is one of Albany's difficult inter-sections, with the recommended control system, and the timing of each light. Traffic movements are differentiated by means of differently shaded lines.

reports submitted to the mayor. They are as follows:

Analysis of Street Accidents.
Parking and One-Way Streets.
Routing of Through Traffic.
Boulevard-Stop Streets.
Automotac Traffic Signals.
Regulation of Bus Stops.
Regulation of Pedestrian Traffic.
Enforcement of regulations.
Permanent Traffic Organization.
Plans for Public Safety Campaign.

These reports were forwarded individually to the mayor, as soon as completed, and were released by him to the local press for immediate publication,

traffic accidents in Albany during 1926, 365, or 43 per cent, were reported as being inattentive. Four were charged with intoxication and one with having a physical defect. The majority of the remainder were due to violation of the state law or accepted safe driving practices; such as not having the right of way, exceeding the speed limit, failure to give the proper signal, improper backing, cutting left corner too shortly, and so on.

Of the 441 pedestrians killed or injured by automobiles, 42 per cent were injured, and 8 of the 11 killed, were children under the age of 14.

Four hundred ninety-one, or 58 per cent, of the drivers involved were between the ages of 25 and 54, 29 per cent were between the ages of 18 and 24, and only five were under 18 years old. Ninety-six per cent of the drivers involved were males, while 4 per cent were females.

From 6 to 7 p. m. appeared to be the time when the largest number of accidents occurred. Wednesday appeared to be the day of most accidents, showing a slight margin over the other days of the week. Just below came Saturday, then Monday, then Thursday, then Friday, and then Sunday.

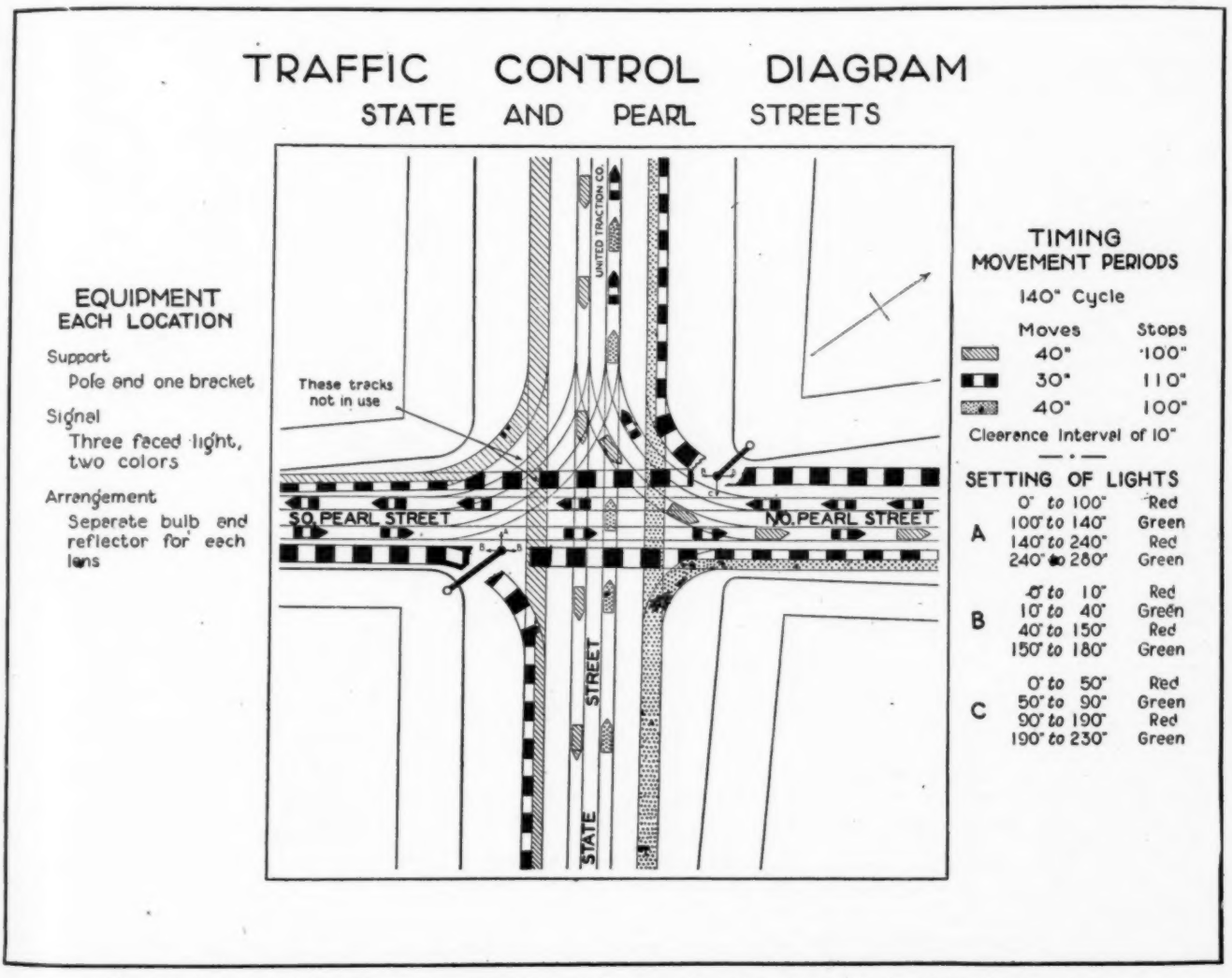


Fig. 3—This sort of intersection is more commonly met in a busy American city. Albany's solution is shown here.

Charting Danger Points.—In gathering the above statistics, the Bureau of Motor Vehicles prepared a spot map showing the location of the different classes of accidents by means of differently colored pins. This map proved of great value in pointing out locations that required special protection, or where some change in traffic handling would be needed.

Traffic Count.—In order that the commission could secure the actual facts showing the quantity of traffic moving on the main thoroughfares, the variation of traffic during the day, and the relative importance of each type of vehicle, a traffic count was made. The City Engineer and the Engineer of the life insurance company cooperating in the work selected 36 significant locations where an actual count could be made, which would indicate the chief thoroughfares used by vehicles entering and leaving the city, the heaviest traveled routes through the city, and the relative travel on the main streets in the congested section.

The Boy Scouts Helped.—Help in making the actual count was secured through the local boy scout organization. Two counts were made during the month of April, one on Thursday and one on the following Saturday, the counts covering the period from 8 a. m. to 6 p. m.

A form was prepared, filled in as to station number, and furnished to the boys. From the data thus supplied, a tabulation was made, diagrams pre-

while running or playing on the streets, 22 per cent were crossing the street at intersections without protection by signals, 17 per cent were jay walking, 10 had their view obstructed, 11 were getting on or off a street car where no safety zone was provided, 4 where safety zone afforded protection, 6 were intoxicated, and 4 were confused by traffic.

Of the 853 automobiles involved, 71 per cent were private passenger machines, 17 per cent were commercial cars, and 7 per cent were taxicabs. Two hundred ten of the 778 persons

pared and traffic flow maps plotted for the city.

Since this count was made before the heavy summer tourist traffic appeared, it indicated with fair accuracy the normal local traffic of the city or originating in the surrounding country. This afforded data for the relative timing intervals for the suggested automatic signal system, and proved of great aid in planning the routing of through traffic. Another count will be made during the tourist season as a check on the timing system in use and to test the efficiency of the through routing system.

Other information was gained from reports on traffic surveys in other cities, available literature, from the reports on the First and Second National Conference on Street and Highway Safety, records of the New York State Bureau of Municipal Information, publications of the signal manufacturers, a report of the Bureau of Foreign and Domestic Commerce of the United States Department of Commerce, entitled "Vehicular Traffic Congestion and Retail Business, and from Miller McClintock's book, "Street Traffic Control."

One Way Streets and Parking.—A revised parking regulation has been drawn, defining parking, designating the methods by which automobiles shall be parked, setting a parking limit of one hour between the hours of 8 a. m. and 6:30 p. m., and designating the locations within the business district at which no parking will be allowed, and at which parallel parking or angle parking will be permitted. Special parking areas were provided in convenient locations.

During the parking survey it was found that 3,500 vehicles could be parked at one time in the business district were no restrictions imposed. With the regulations in force at the time of the survey, about 2,700 vehicles could find parking space. Under the proposed regulations about 2,200 could be accomodated. With the one-hour parking limit strictly enforced, 22,000 cars could be parked for one hour each during the business day. This was about one-third of the total number of cars registered in the county at the time of the survey.

Parking Defined.—The report on parking defined parking as follows: "The permitting of a vehicle of any description, whether occupied or not, to remain stationary upon a public street for a greater length of time than is required to take on or discharge passengers or to load or unload freight."

The proposed code specified parking parallel to the curb line, within six inches of it, except where angle parking would be permitted. The grades on some streets in that city that it was found necessary, for the sake of safety, to specify that where angle parking would be permitted, the cars must be parked at right angles to the curb, heading to the curb line. Other parking rules were included, for police and fire department reasons, and to prevent blocking of driveways, sidewalks, and so on.

Special Measures.—Bus stops and terminals, street car stops, street widening, cross-walk lines, traffic signs, and other details were provided for as well. Provision was made to designate certain streets as through routes, to remove the tourist traffic from the main business streets except for those tourists who might desire to visit that section.

In order that the flow of traffic might be broken up for the sake of safety to cross traffic, certain intersections were to be posted as boulevard-stop streets.

Automatic Traffic Signals.—Because of the large variance in the width of streets and lengths of blocks, the non-rectangular layout of streets and the extreme grades, particularly within the business district, it was found that the design of the automatic traffic signal system required very careful study and planning. These conditions necessitated several rather unusual suggestions in the proposed plan, which appear complicated on paper, but which should prove simple in actual operation.

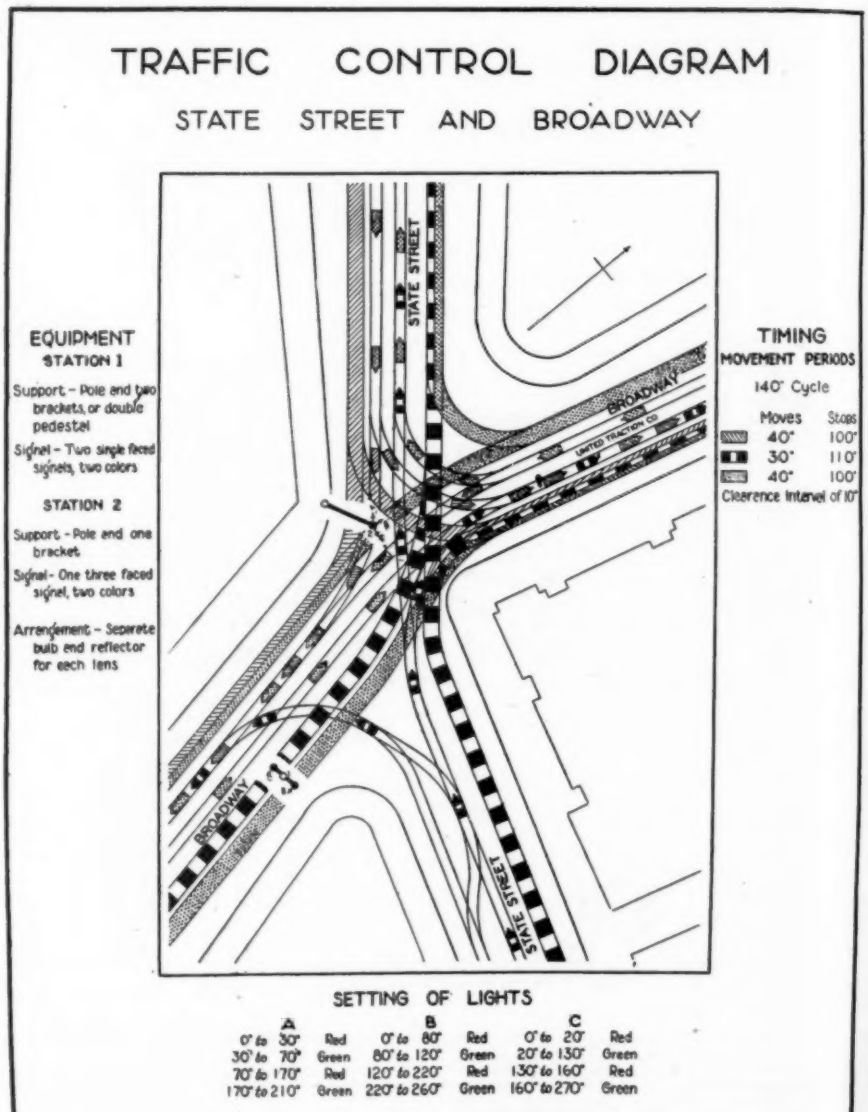


Fig. 4—Another type of crossing that can lead to confusion. Note how two lights will control this traffic.

One feature was that the two-light system was recommended instead of the three-light system. The commission felt that the usual amber light does not allow the intersection to be cleared, but results in drivers trying to "beat the lights" and end up in a dangerous traffic snarl. Instead the traffic change is marked by the red light showing in both directions, bringing all the traffic to a complete stop during the interval except for those vehicles and pedestrians actually clearing the crossing.

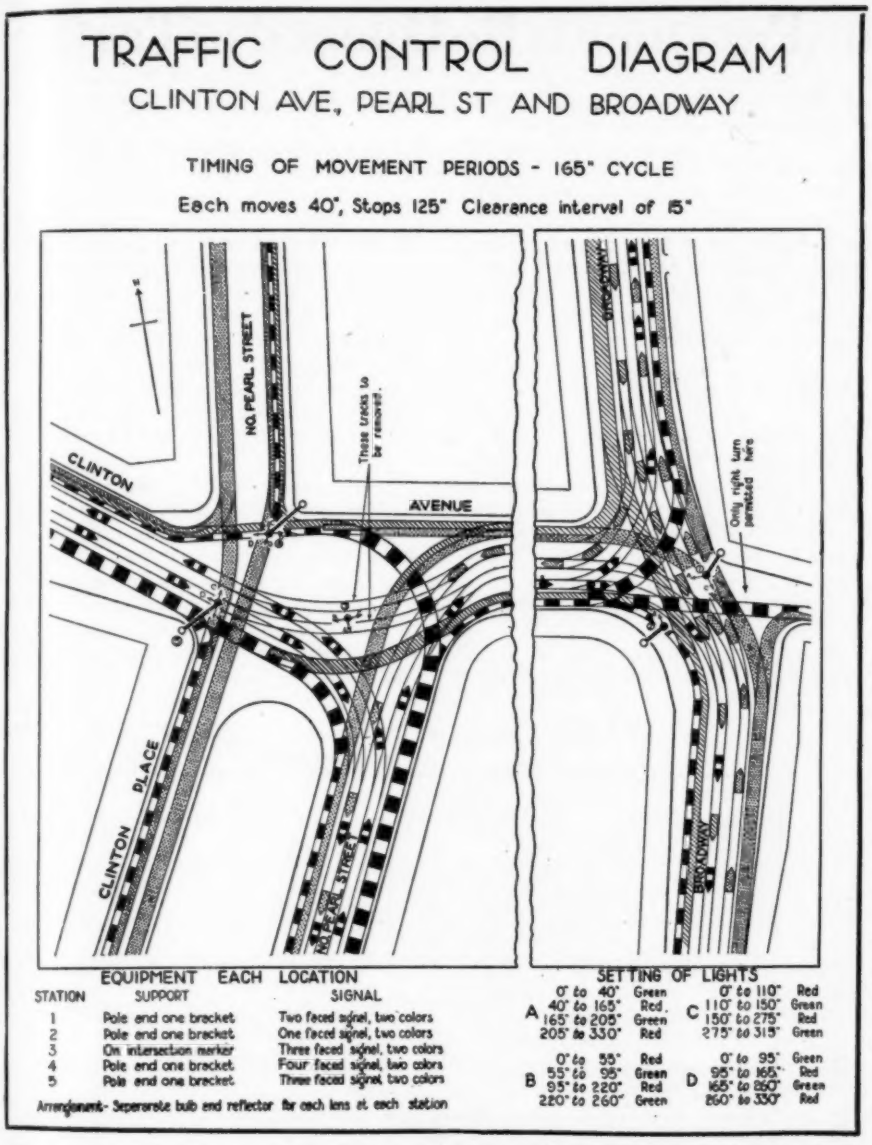

TRAFFIC CONTROL DIAGRAM
CLINTON AVE., PEARL ST AND BROADWAY
TIMING OF MOVEMENT PERIODS - 165" CYCLE
Each moves 40", Stops 125" Clearance interval of 15"
NO. PEARL STREET
CLINTON
AVENUE
These trees to be removed.
Only right turn permitted
CLINTON PLACE
MAIDEN STREET
BROADWAY
EQUIPMENT EACH LOCATION
STATION SUPPORT SIGNAL
1 Pole and one bracket Two faced signal, two colors
2 Pole and one bracket One faced signal, two colors
3 On intersection marker Three faced signal, two colors
4 Pole and one bracket Four faced signal, two colors
5 Pole and one bracket Three faced signal, two colors
Arrangement- Seperate bulb and reflector for each lens at each station
SETTING OF LIGHTS
A 0" to 40" Green
40" to 165" Red
165" to 205" Green
205" to 330" Red
B 0" to 55" Red
55" to 95" Green
95" to 220" Red
220" to 260" Green
C 0" to 110" Red
110" to 150" Green
150" to 275" Red
275" to 315" Green
D 0" to 95" Green
95" to 165" Red
165" to 260" Green
260" to 330" Red

Fig. 5—Here is about the worst sort of a case that the engineer will meet, yet it was solved with but 5 signals, as indicated in the diagram and chart.

Automatic signals were to be placed at twenty locations, at twelve of which the bracket type was recommended.

Several Typical Intersections.—Several typical intersection plans are reproduced herewith. As the diagrams show, three distinct movements of traffic have been provided, each shown with a differently shaded line. The location, type, and timing of the automatic signals, also shown, were designed so that vehicles would be permitted by signal to move along only one of the routes at a time, all other vehicles being required to stop. The shaded arrows, shown between the car tracks, indicate that street cars on the particular tracks are to move with the vehicular traffic in the route designated by the line shaded in the same manner.

A study of these diagrams will afford suggestions on the control of traffic under similar conditions in other cities.

Inspection Superintendents. — The U. S. Civil Service Commission, Washington, D. C., has announced open competitive examination for the positions of chief engineering inspection-superintendent at entrance salary of $2,400 per year and senior engineering inspector-superintendent at $1,860 per year. Applications for these positions must be on file with the Civil Service Commission at Washington, D. C., not later than March 29. The examinations are to fill vacancies in the Bureau of Public Roads, for duty in the States of Washington, Oregon, Idaho, Montana, California, Nevada, Arizona, Utah, Wyoming, Colorado, New Mexico, and the Territory of Alaska.

Arkansas to Spend $52,000,000 on Road Building.—The state legislature of Arkansas has passed a bill providing for the expenditure of $13,000,000 per year for a period of four years for road building.

Grading Methods in North Dakota

J. E. O'Neil, construction engineer, of the North Dakota Highway Department, makes the following interesting statements in a recent issue of the North Dakota Highway Bulletin:

Most grading work in North Dakota, he said, is done by excavating graders and dump wagons, although a few of the contractors have been operating steam and gas shovels. These are used most extensively in the Band Lands and rougher portions of the state where short, deep cuts and sharp breaks are encountered. Fresno scrapers are generally used for finishing road surfaces, although some of the smaller contractors use them in their general grading work.

It was found from past experience that a road finished to a uniform grade line, before being compacted under traffic, is far superior to one roughened in and later finished by adding extra material to the depressions where such earth was omitted on first construction. The objection to the latter method is, that where a road is constructed with a wavy surface and extra material added later to eliminate such waves, that the same does not form a bond with the compacted material and results in considerable waste caused by continual shifting and blowing away. This is perhaps a more noticeable feature in prairie states where wind breaks are lacking. This method of construction brings about conditions which are hard to remedy and cause a continual increase in the cost of maintenance.

Another feature that requires careful attention in order to eliminate waves in the consolidated or settled road is adequate provision for settlement in embankments or fills. When a uniform gradient extends through a cut and crosses a fill, the fill must be built sufficiently high above the profile elevation so that when settlement takes place, the consolidated fill may be true to grade. The above condition would apply more specifically to projects constructed within the Bad Lands where sudden breaks in profile of over 10 to 40 ft. cause considerable settlement where the cut runs out and the fill begins.

Tying Up With Radio

The Missouri State Highway Commission is instituting a new method of opening bids "in public." Taxpayers can now sit in their own homes or offices and yet "hear" the proceedings at Jefferson City, since the proceedings are broadcast from radio station WOS. Such a broadcast was held on Feb. 26, when sealed proposals were opened for the construction of roads and bridges totaling over 17 miles.

When May Concrete Pavements Be Opened to Traffic

A Simple Cantilever Method of Test for Determining Cross Bending Strength of Concrete

By H. F. CLEMMER
Solvay Sales Corporation, New York

With the enormous increase in traffic, the economies in transportation effected by road improvements have become very important to the public.

A few years ago, when there was but a small mileage of improved roads and a comparatively small volume of traffic, as compared to the present conditions, the importance of opening a concrete road to traffic as soon as possible, was not realized. However, with the advent of motor traffic, and data available as to the cost of using detours as compared to the finished pavement, not considering the inconvenience caused the public, the urgency of permitting the traffic to use the road as soon as the concrete had gained adequate strength has been demonstrated. Also the development of ceemnts, special mixes, and accelerators which produce early strength concretes, has made possible early use of pavements which has heretofore been impracticable.

Arbitrary Length of Time for Curing.—In the past, engineers have specified an arbitrary length of time for the curing of concrete pavements before opening to traffic, not taking into account the fact that all concrete does not gain strength at the same rate. The different materials and methods used in manufacturing the concrete particularly affect the early strength of the concrete. It was seldom that early strength tests of any kind were made, and then only in compression which does not necessarily indicate the resistance to cross bending, the manner in which concrete pavements fail.

Even though the length of time set for curing in the past was generally twice that required at the present time, still, without question, many of the pavements were opened to traffic before the concrete had gained sufficient strength, when conditions for curing were not of the best, such as during the fall months when the temperature is low. It is certainly important that the cross bending strength of the concrete be known before it is subjected to loads which might cause it to fail rather than to set an arbitrary length of time for the curing, which in some cases is much longer than is necessary for the proper curing of the concrete, and in other cases, curing conditions being unfavorable, the concrete has not gained the necessary strength to support the loads imposed upon it.

Design Theory for Concrete Pavements.—The theory upon which a large number of highway departments are basing their design of concrete pavements, is that of the maximum wheel load placed at a free corner; no subgrade support is taken into account, so that the corner of a slab is considered as a cantilever. Substituting the moment for a cantilever in the simple formula $S = \frac{Mc}{I}$, we have $S = \frac{WLc}{I}$, the actual stress which should be caused by this load with a given thickness of slab and under the conditions imposed. This formula was applied to pavement design during the Bates Road Tests by Mr. Older and fully discussed by him in a paper presented to the American Society of Civil Engineers in 1924.

When it is realized that a definite maximum load is considered in determining the thickness of concrete necessary for a pavement, the importance of restricting all loads to this given limit may be understood. If, at any time permission were granted to increase this maximum load, a real danger would be incurred as to the life of the pavements which have been built with the limit used as a consideration in their design.

It is true the factors, such as fatigue, etc. must be taken into account in determining a safe working unit stress. When there is this possibility of fatigue occurring, that is, when the pavement will probably be subjected permanently to a large amount of heavy traffic, it is found that a factor of 2 should be used, that is a working unit stress of about

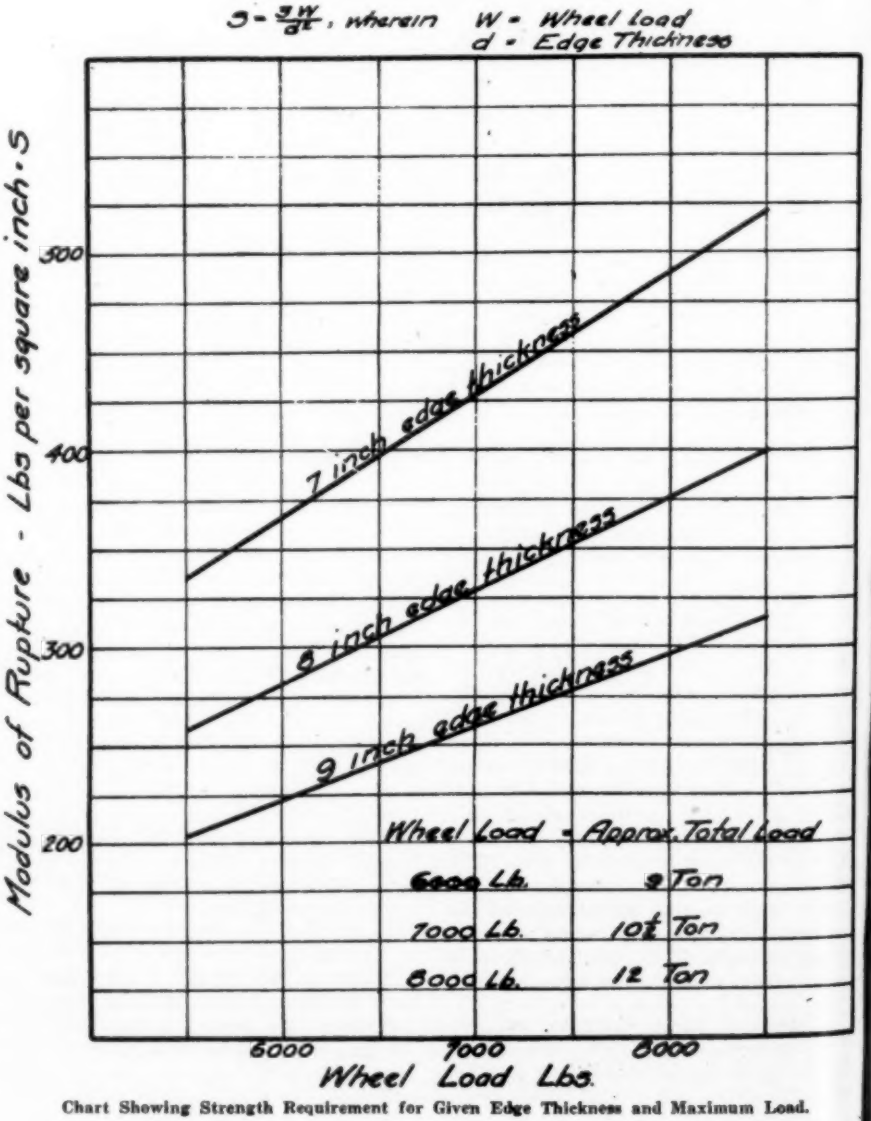
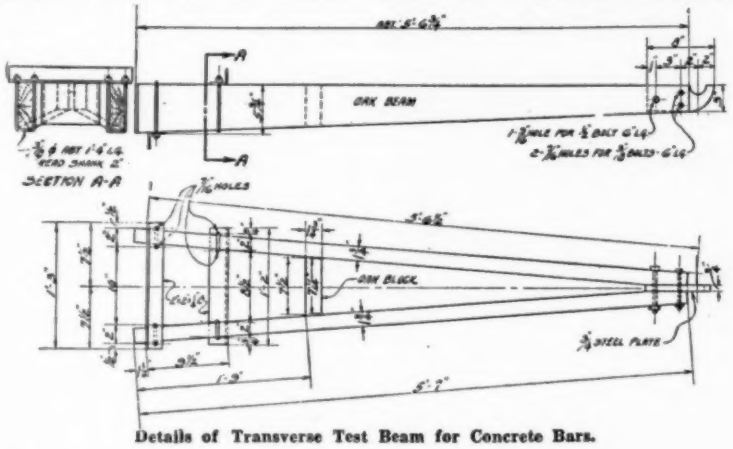


Chart Showing Strength Requirement for Given Edge Thickness and Maximum Load.

one-half the ultimate strength of the concrete should be used in determining the required thickness of concrete for the pavement which is to support definity loads.

When the demand for early opening of a pavement is to allow the contractor to truck his materials over the slab, as is often of great help economically and in speeding up construction, especially when half widths of pavement are being built, it is possible to require the trucks to keep in the center of the slab, which can easily be done by placing obstructions, such as timbers or rock, along the edges of the pavement. This will keep the loads from coming directly on a free corner and there will be a sufficient factor of safety to offset the possible fatigue which might occur under such conditions.



Details of Transverse Test Beam for Concrete Bars.

Matured Strength of Concrete.—There has been considerable discussion as to what the matured strength of concrete should be for pavements but that discussion has dealt with the pavements under the most adverse conditions, that is:

When the slab may not receive any definite subgrade support, as is probably the case when the frost is leaving the ground in sections having a subgrade which holds a large per cent of moisture.

When the traffic consists of a large number of heavy vehicles which might cause fatigue. When the loads are applied directly on free corners of the slab formed by the occurrence of transverse cracks due to temperature changes.

But there has been very little discussion as to what the strength of the concrete should be under the conditions at the time of opening a new pavement. There are many conditions which pertain during the early curing of a concrete pavement which are factors of safety so that when the strength of the concrete in the road has reached the unit working stress used in the formula it is safe to subject it to the loads considered, that is, it is not necessary to use a factor as referred to above to take care of possible fatigue, etc.

The slab would, without question, receive considerable subgrade support for at least a period long enough for the concrete to gain its full strength.

It is probable traffic would not reach a point such as to cause fatigue. Light loads such as pleasure vehicles, which do not stress the concrete beyond 50 per cent of the modulus of rupture will not be a contributing cause for fatigue.

Obstructions may be placed along the edge of the slab so that the loads would not be applied directly on a free corner, at the edge of the pavement.

When dowel bars are used across construction joints free corners would be eliminated, for the dowels should function perfectly, especially when the pavement is new.

All of these factors serve as measures of safety against non-uniform concrete or other conditions affecting the uniform strength of the concrete.

Cross Bending Strength of Concrete.—Therefore, if the cross bending strength of concrete specimens which are made of the same concrete as the pavement slab and cured under exactly the same conditions as the concrete in the pavement, is determined at various ages, it is entirely safe to open the road to traffic as soon as the concrete has attained a strength sufficient to support the maximum load which is to be permitted on the pavement, as determined by substituting in the formula referred to above. Especially should this matter receive attention when the inconvenience and the cost to the public is taken into account.

There is no more reason to prohibit traffic from using this pavement under the above conditions than to refuse to permit the maximum load on the pavement which was considered in designing for the quality and thickness of the slab.

A chart is given which shows the strength of concrete as modulus of rupture in pounds per square inch which must be obtained before traffic of the given maximum loads should be permitted to use the pavement.

The concrete should be so designed that the matured strength will be twice that at which the pavement may be opened in order to take care of fatigue and impact, which may occur under later conditions, and of free corners which may develop later due to transverse cracks and at a time when the concrete is contracted and the slab allowed to move.

Cantilever Method of Test.—A simple cantilever method of test has come into quite general use in determining the cross bending strength of concrete.

The machine consists of an extension arm which may be fastened to the free end of a specimen beam which is held in cantilever. The load is then applied by pouring some free running material at a uniform rate into a container which is fastened to the end of the cantilever arm. This simple method of test has made possible field testing

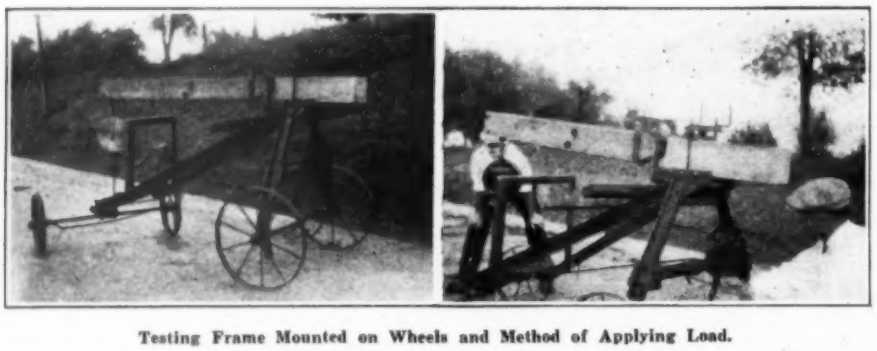
Testing Specimen Clamped to Rear of Truck; Water Is Being Used as Loading Medium.

which requires little labor and expense and gives results which are directly indicative of the true strength of the pavement concrete*.

For this purpose test beams are made in forms from the same mix as used in the pavement. These specimens are allowed to cure under the same conditions as the pavement concrete and are broken at regular intervals in the field with this simple testing device.

The specimens may be held in cantilever by clamping to the rear end of a truck or other improvised platform. The loading medium can be water which may be measured and the load thus determined so that scaled will not be required on the job.

A very satisfactory frame work for holding the specimens and by means of which the load may be applied and measured with a dynamometer has been devised by the Testing Department of the Minnesota Highway Commission. This machine has proven very convenient and very satisfactory for use in the field. Care should be used to be sure the dynamometer is properly calibrated, and that the load is uniformly applied so as not to cause the effect of impact or fatigue while testing.



Testing Frame Mounted on Wheels and Method of Applying Load.

Advantages of Cantilever Test.—The advantages of this test as compared to the former method of determining the compression strength are:

The saving in cost and time, as the apparatus necessary to make the test will cost but a few dollars and may be assembled in the field.

That the method will give more uniform results due to the manner of testing.

That the specimens may be tested in the field and therefore the concrete is tested under exactly the same conditions as those existing in the road slab.

The cross bending strength is determined rather than the compression strength which is not necessarily indicative of the cross bending strength of the concrete, the manner in which concrete pavements fail.

The practice of making these tests in the field and opening the pavements to the public as soon as the concrete has increased in strength to that used in the design formula is being adopted by many state highway departments.

On most public highways at least 90 per cent of the traffic consists of light weight traffic, such as pleasure vehicles, etc. This class of traffic should not be held from the pavement until sufficient strength is reached in the concrete to carry the heavy truck loads. It would certainly seem advisable to expend what may be required to properly police the road so as to make it satisfactory to allow the light traffic to use the pavement for which the strength is fully adequate and preclude the heavy traffic which might cause failure until the concrete has gained greater strength. A determination of the saving which will result to the public in being allowed to use the concrete surface, rather than being required to use the provided detour for even a short time will prove the importance of this matter.

The State Highway Department of Pennsylvania has been carrying on this manner of testing to a considerable extent and recently opened a pavement to traffic in 89 hours. The maximum load which was to make up the traffic was taken into account as was the edge thickness of the concrete slab and the road was opened to traffic when the tests showed the concrete had gained sufficient strength as determined by the design formula. Proper care in making the concrete and ideal curing conditions were undoubtedly responsible for the early strength of the concrete but unless the cross bending tests had been made and the strength required to carry the traffic determined from the design formula it would have been unwise to risk opening this pavement to traffic in such a short time.

This indicates the rapid advancement that is being made in highway construction practice.

*—"Transverse Testing of Concrete," American Concrete Institute, February, 1926.

Ruling on Kansas Road Law.—The Kansas Supreme Court has handed down a ruling upholding the state road law now in force, except that the ruling declared that the $1,200,000 state aid road fund should be distributed to counties in accordance with their requirements, the state paying one-fourth of the cost of state aid roads out of that fund.

Announce Abram's Resignation

The Portland Cement Association announces with regret the resignation of Duff A. Abrams, for many years Director of the Research Laboratory. Professor Abrams inaugurated the present-day research in concrete when he took charge of the Structural Materials Research Laboratory in 1916. The research program, then begun, was supported by cooperation of Lewis Institute and Portland Cement Association. This joint arrangement continued until May, 1926, when the Research Laboratory was installed in the new headquarters building of the Portland Cement Association at 33 West Grand Ave., Chicago.

Professor Abrams' work in concrete research is internationally known. His bulletins and scientific papers have been translated into many languages and are standard reference works in concrete technology.

Prior to his connection with Lewis Institute, Professor Abrams was a member of the faculty staff of the University of Illinois, of which he is a graduate.

F. R. McMillan, manager, Structural and Technical Bureau, Portland Cement Association, has been appointed director of research to have charge of all investigations in cement and concrete for the Portland Cement Association. Mr. McMillan has been a member of the headquarters and laboratory staffs since April, 1924. Prior to that time, for three years he was associate structural engineer with Adolph F. Myer, consulting hydraulic engineer of Minneapolis. He was also on the staff of the Turner Construction Co. for some time and was in charge of concrete ship design for the Emergency Fleet Corporation, United States Shipping Board, during and subsequent to the war. For nine years Mr. McMillan was on the faculty staff of the University of Minnesota in charge of concrete design in the concrete laboratory. He is a graduate of the University of Minnesota.

H. F. Gonnerman, associate engineer, Research Laboratory, Portland Cement Association, has been appointed Director of the laboratory. Professor Gonnerman joined the staff of the laboratory in 1922. Prior to that time he was in a private business in the Far West and from 1908 to 1920 was on the faculty staff at the University of Illinois, of which he is a graduate. Professor Gonnerman is joint author of many of the Research Laboratory bulletins and while on the faculty staff at the University wrote a number of technical and scientific papers which received wide attention in engineering and technical circles. For many years he has been active in the American Society for Testing Materials and other technical and engineering societies. He is well known among engineers and research men throughout the country.

Resurfacing Old Brick Pavement

Method of Laying Asphalt Surface at Ashland, O.

By R. L. WILLIAMS
City Engineer, Ashland, O.

The first resurfacing of old brick pavements in Ashland, O., was completed in September, 1926, and both the city officials and property owners on the street are well pleased with the results. Undoubtedly several other streets in the city which have been paved from 15 to 25 years will be improved in somewhat the same manner as Fourth St.

The original pavement on Fourth St. was constructed in 1906 and consisted of 4-in. brick block on 9 in. of native gravel with sandstone curbing. Valley gutters carried across intersecting streets caused motorists much inconvenience and discomfort.

Pavement Cuts Cause Roughness.—One of the main causes for the unevenness of the brick pavement was the constant repair of the water service lines. The records in the water department show that from 15 to 20 leaks each year were repaired which necessitated an opening in the pavement with the attendant settling of the trench and misplacement of the relaid pavement.

Another cause for the rough surface was attributed to the fact that the surface drainage was carried about 1,800 ft. before it entered the sewer. The block being sand filled much of this water seeped through to the subgrade and made it more or less spongy at all times.

View of Street After Resurfacing.

Fourth St. parallels the main industrial district of the city and is subjected to considerable heavy traffic.

The Preliminary Work.—Taking all the above conditions into consideration, we proceeded as follows: A bond issue of $14,200 was passed by the council. Part of this was used by the water department to place a 2-in. galvanized steel pipe line back of each curb the full length of the street which supplies all service lines.

Fourth St., Ashland, O., Before Resurfacing.

Openings were made in the street over the 6-in. cast iron water main where services connected. These were disconnected and the hole backfilled and subjected to traffic. Care was taken to keep these trenches well filled with cinders. About two weeks before the resurfacing material was applied the trenches were dug out to a depth of 6 or 8 in. below the surface of the brick pavement and 2 ft. longer each way than the original cut. This provided a 1-ft. shoulder of undisturbed earth for the reinforced concrete patch which was made flush with the old pavement. The 6-in. water main which at one point crossed the 48-in. brick storm sewer was lowered to pass under the sewer and the opening patched as described above.

The remainder of the bond issue was used to build catch basins and sewer on one of the intersecting streets and for the city's share of the resurfacing.

The contract for resurfacing the street was awarded to the Mansfield Asphalt Paving Co. of Mansfield, O. H. S. Scott of Ashland, O., constructed additional catch basins of which there were six, and built concrete curb circles at intersecting streets replacing the old 6-ft. circles with those of 15-ft. radius.

Preparing Old Surface.—The street was then rolled with a 12-ton road roller, starting at the curb and successive trips of the roller were lapped until the center of the street was reached. The rolling along the curb was especially beneficial as many of the brick

projected an inch or more above others; and up to two inches additional curb heighth was obtained by the rolling.

After the rolling was completed the street was thoroughly cleaned by flushing and sweeping, care being taken to see that no loose material remained in the joints.

Laying New Asphalt Surface.—As soon as the pavement was dry the binder course was laid and thoroughly compacted by rolling, two tandem rollers being on the job at all times. Then followed the top course of sheet asphalt which was subjected to the same treatment as the binder course. Liberal use of a 10-ft. straight edge on the top course guaranteed an even, smooth riding surface and all high spots thus found were rolled until they disappeared.

The curbs and gutters were painted with asphalt before application of the sheet asphalt wearing surface.

Texaco asphalt was used for the resurfacing, which consisted of a 1½-in. sheet asphalt wearing surface and a 1½-in. binder course. The valley gutters at intersecting streets were filled in, making it a pleasure to drive across this street.

The materials for both binder and top course were tested and mixed at the asphalt plant in Mansfield, O., and hauled by truck 14 miles to the job, at which point it arrived in fine condition.

Plant inspection was handled by The James H. Herron Co. of Cleveland, O., H. A. Slippy being in charge.

The cost of the new water lines, replacing the services, cementing the patches, constructing four catch basins and about 500 ft of 12-in. sewer were paid by the city. The cost of the resurfacing was divided equally between the city and property owners, making the cost to the property owners $1.58 per front foot, the pavement being 30 ft. in width.

Annual Convention of American Association of Engineers.—The next annual convention of the American Association of Engineers will be held at Tulsa, Okla., June 6-8, 1927. The convention will be held at the same time as the annual meeting of the Oklahoma Division, A. A. E. Members and friends of the association are invited to be present. M. E. McIver, 63 East Adams St., Chicago, Ill., is acting secretary of the association.

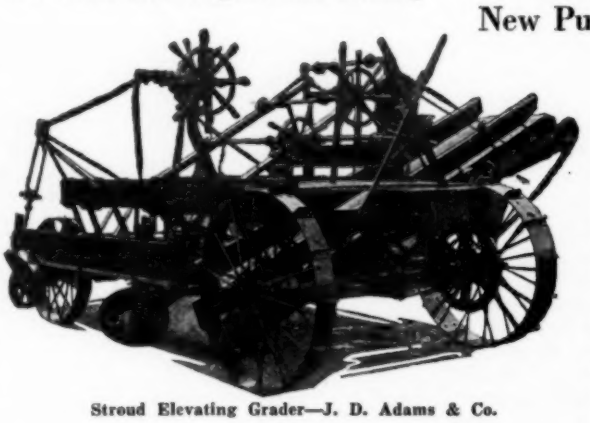
Cost of Collecting Gas Tax

According to French T. Sheets, chief highway engineer, Illinois, the average state spends about 70c for every vehicle registered in collecting its gas tax. Where the gasoline tax is collected at the source, the cost runs around 2.64c per $1,000, while Uncle Sam spends $22.50 per $1,000 in collecting customs, and $12.10 per $1,000 for collecting internal revenue.

J. D. Adams & Co. Takes Over Sale of Stroud Elevating Graders and Wagons

J. D. Adams & Company, Indianapolis, Ind., has taken over the exclusive United States and Canadian sales rights to Stroud elevating graders and dump wagons. These products will now be sold by the Adams sales organization, consisting of direct factory sales representatives and distributors throughout the United States and Canada, with branches in Spokane, Minneapolis, Kansas City, Dallas, Memphis, Harrisburg, Winnipeg, and Toronto.

Stroud machines, manufactured by The Little Red Wagon Manufacturing Co. of Omaha, Neb., successors to Stroud & Co., have been used in all parts of the country for 28 years. Stroud elevating graders have earned an enviable reputation with contractors because of their ease of operation, large capacity, durability and low cost of upkeep. The Stroud Grader is furnished in three sizes—Stroud senior grader, with 36-in. belt and weighing 9,975 lb.—a standard model most frequently used for building roads, ditches and embankments on a moderate scale; Stroud master grader, with 36-in. belt and weighing 11,682 lb.—for the bigger contractor; Stroud heavy duty grader, with 42-in. belt and weighing 11,790 lb.—specially adapted to the handling of material in large clods and pieces.



Stroud Elevating Grader—J. D. Adams & Co.

Stroud's wagons are bottom dump wagons, horse drawn, for hauling dirt, rocks, gravel, etc., and may be loaded by power shovels, elevating graders or by hand. Stroud wagons are offered in two sizes—the Stroud special wagon of 1½-yd. capacity and the Stroud "Little Red" wagon of 2-yd. capacity, both furnished in three models as follows: Model A, chains run through side of body, connecting with doors at the center of the bottom edge; recommended for dirt work because it is easiest to pull off the load. Model B, chains pass under or on the outside of the doors; used where sand tight box is required or where wagons are used under power shovels, where rocks are large enough to break chains. Model C, same as Model A except that each door is suspended by a pair of chains, one at either end.

"Little Red" Dump Wagon, Model A, 2 Yd. Capacity—J. D. Adams & Co.

New Pumps Have Novel Oiling System

Three new pumps now being introduced by the Novo Engine Company, Lansing, Mich., have a novel oiling system known as "Flud Oild." The new pumps are of the pressure type, and are of particular interest to the road builder.

The oiling feature is said to insure automatic lubrication of every moving part. The pump crankshaft gear runs in a bath of oil, and revolving, brings oil up to the "Flud Oild" gear at the top. This small gear, the only moving part in the lubrication system, through an arrangement of oil ducts in its teeth, discharges oil under pressure to both sides of the pump crankcase. Troughs lead the oil to crosshead, pin and all bearings, while the connecting rod, in addition to dipping in the oil, is sprayed with oil from the small gear at the top of each stroke. In type "EW" duplex double acting piston pumps, the oiling gear is located in the middle of the pump.

The new single cylinder enclosed piston pump is a double acting, inside packed pump, powered with Novo one and two cylinder gasoline engines or electric motors. The new two cylinder enclosed piston pump is a double acting inside packed pump, powered with Novo one and two cylinder gasoline engines or electric motors.

The Triplex pump, especially designed for road builders, is the right size for operating with a 27 E paver, and has a capacity up to 70 gal. per minute at 500 lb. pressure. It is powered with a Novo N. F., 25 h. p., 4-cylinder engine and is mounted on a steel truck.

Street Widening in Chicago

What Is Being Done to Relieve Traffic Congestion, Described in Paper Presented Before Illinois Society of Engineers

By J. A. MOORE
Engineer in Charge of Surveys and Estimates, Board of Local Improvements, Chicago

The rapid growth in population in the city of Chicago, together with the material prosperity of its citizens, as evidenced by the ever increasing number of automobiles, has resulted in street congestion to such an extent that the municipality has been forced into adopting an extensive program of street and roadway widening. The need of wider streets was foreseen a number of years ago by the late Daniel H. Burnham and his associates who formulated a comprehensive scheme of municipal improvements commonly called the "Chicago Plan," which designated a considerable number of main arteries of travel for widening as well as the double decking and beautifying of such improvements in the downtown district of the city as the Boulevard Link on Michigan Ave. and the recently completed Wacker Drive.

The Western and Ashland Ave's. Widening.—Among the streets so designated were Western Ave. and Ashland Ave. main north and south section line streets which extend practically across the entire city, and are between 20 and 30 miles in length. These streets which in the main were 66 ft. wide were ordered to be widened to 100 ft. by the Board of Local Improvements within whose province such work comes. Very considerable progress has been made in carrying out these widenings; the policy being to widen the outlying and less densely built up sections first. The widening of Western Ave. has been completed on the south side and on the north side as far south as Belmont Ave., a total distance of 16½ miles. Ashland Ave. has been widened on the south side from 47th St. to 95th St., a distance of 6 miles, and on the north side from Winnemac Ave. to Devon Ave., where a portion of it merges into North Clark St., a distance of 1½ miles. However, not all of the work of repaving of these widened thoroughfares has been completed, a considerable section of both streets being now under contract.

The Widening Policy.—It has been the policy of the Board of Local Improvement to widen these thoroughfares uniformly to 100 ft. with roadways of 70 ft. and walks of 15 ft. in width. The scheme of improvement of the widened roadways varies somewhat with the character of the present improvements. Considerable portions of the present pavement is of granite blocks which are in fairly good condition, and which will be relaid, the old blocks being placed on the outer portions of the roadway and new blocks used sufficient to complete the paving; the new blocks being placed on the central sections of the roadways where the traffic will be heavy. The old foundations will generally be used and brought up to the proper grade by adding a new layer of concrete to that now in place. Some of the older sections where the present concrete foundations are in poor condition will be entirely repaved with asphalt on new 8 in. concrete. In these sections where business houses demand the improvement of the entire sidewalk space, the walks will be constructed ahead of the pavement and a combination curb and walk built.

In co-operation with and supplementing the work of the Chicago Plan Commission, which plans and promotes improvements which may be termed intramural, is the work being done by the Chicago Regional Planning Association which has a very extensive scheme for providing interurban wider highways, connecting up in most instances with the widened roadways within the city.

Of late there has been a general and rapidly growing demand within the city for wider roadways on business streets carrying car tracks. It has been conclusively shown that the street space allotted to sidewalks and that allotted to roadway are entirely disproportionate. The present 38 ft. roadways on 66 ft. streets may be widened to 48 ft. without serious inconvenience to pedestrian traffic, provided shop keepers are required to keep their wares inside their buildings. Similarly, 48 ft. roadways on 80 ft. streets may be widened to 60 ft.

Retaining Wall Problem.—The central section of the city of Chicago is built on ground that was originally low and marshy. The natural surface of the ground is 6 or 8 ft. below the present street level. When the streets were filled retaining walls of rubble stone were built on the curb lines. The space between the curb lines and the building lines being unfilled and having sidewalks built over it was utilized by the abutting property owners for storage of coal, disposal of rubbish, etc. The use of this space has grown with the lapse of time. Some of the sub-sidewalk space in the downtown section is excavated and utilized to a depth of 30 ft. or 40 ft.

The widening of roadways, therefore, means the reconstruction of these retaining walls, which are usually about 10 ft. in height. In their reconstruction, concrete walls of gravity type are used, the footings extending down to 2 ft. below the floor level of the sub-sidewalk space. Where streets are widened and the buildings cut off or moved back, if it is found necessary to build retaining walls they are built adjoining the new street lines, thus eliminating the sub-sidewalk space, and allowing the full use of the street for pipe and conduits. The use of the space under the surface of the street by the abutting property owners is objectionable from a public standpoint, but hard to eliminate. Recently the property owners in a section of Wabash Ave. in the downtown district requested the city to prepare plans for widening the roadway 5 ft. on each side of the street, but desired to retain the use of the entire present sub-sidewalk space. As some of this space is three floors deep, the preparation of the plans involved some difficult engineering problems.

Chicago Ave. Job Involved Interesting Features.—One of the widening projects which the writer had charge of during the past year was the widening of the roadway and repaving of Chicago Ave. from North Clark St. to Larrabee St., a distance of about six-tenths of a mile. This street is 100 ft. wide and was paved with brick about 30 years ago. The old roadway was 50 ft. wide; the new is 70 ft. wide, 10 ft. on each side of the roadway being taken off the sidewalks and added to the pavement. The old sidewalks were 25 ft. wide, nearly all over vaults, and of many types of construction, some consisting of stone slabs about 8 in. in thickness, a type of walk extensively used about 35 years ago. The supporting beams of the old walks were badly corroded. Extensive shoring was required before proceeding with the cutting off of the walk. The walks were cut off with a concrete breaking outfit, the beams being burned off with an oxygen acetylene torch. The cut off sections of walk were loaded into trucks by chaining them to the dipper of a steam shovel. In some cases it was necessary to use a crane equipped with a clamshell bucket to remove the rubbish which had accumulated under the walks. The walks were cut 6 in. back of the new curb lines. The footings of the new concrete curb walls are 2 ft. in thickness and built so that the top conforms to the basement floors, which are usually of concrete. The walls are 12 in. wide on top. The inner 6 in. of the top of the wall supports the cut off walk while the outer 6 in. is built up to conform to the upper surface of the walk, and forms the curb. Concrete slabs 8 in. in thickness and 7 ft. in width were built adjoining the new curb lines, the gutters being formed in these concrete slabs and located 6 ft. from the curb lines. The old brick pavement including the foundation was removed. The new foundation of that part of the roadway outside of the concrete slabs is 8 in. in thickness, the wearing surface standard sheet asphalt except 2 ft. on each side of and adjoining the car tracks, which is of granite blocks.

The concrete slabs adjoining the curb lines were used with the idea of furnishing the pavement with an unyielding surface on that part of the roadway commonly used for parking purposes and thus avoiding the unsightly marking which often occurs in the sur-

face of an asphalt pavement used for parking purposes in hot weather. The gutters were left in their former location because that type of construction obviated the construction of new sewer connections and also because it gave a lesser height of curb, as the car tracks which govern the depth of gutter were somewhat below grade. The top of the new curb is about 2 in. higher than the top of the old curb, due to the slope of the sidewalks.

This type of construction seems to have pleased the property owners in the vicinity of the improvement, as they have requested a number of other improvements of a similar type.

The Clinton St. Widening.—Another widening job completed during the last year was that on Clinton St. from Harrison St. to Roosevelt Road. This is the first of a series of five streets in the quarter section south of Harrison St. and east of Halsted St. The streets in this vicinity, as originally laid out, were 40 ft. wide, with 28-ft. roadways. It was intended as a cheap residence section. It was here where the historic O'Leary cow kicked over the lamp and started the great Chicago conflagration of 1871. Had these streets been wider it is likely that the fire would never have gotten beyond control. This 40-ft. street was widened to 80 ft., 20 ft. being added on each side. The new roadway is 56 ft. wide, and paved with granite block on a 10-in. concrete foundation. Most of the buildings along the street were wrecked and made way with for the better class of improvements that are sure to follow. The improvement of this street presented no unusual features except that the area of the old basements, which were frequently quite deep, was cleaned out to the bottom, were found filled with building rubbish, and refilled with sand in order to secure a stable foundation. The placing of granite blocks was completed about Dec. 15, in cold weather. In order to prevent the grout filler used in the pavement from freezing, water heated in the tar tank and treated with a liberal dose of salt and sand heated in an asphalt plant was used. Steam and rock salt were used to take the snow and ice off the concrete foundation and off the piles of granite blocks.

The Widening of Madison St.—Another widening job which might be mentioned was completed on Madison St. between Cicero Ave. and Austin Blvd. A 50-ft. roadway, on a 120-ft. street, was widened to 80 ft. The old pavement was brick on a concrete foundation. The new pavement is asphalt. The concrete foundation in the old roadway was salvaged and brought up to grade with asphalt binder or "black base."

A similar widening job was completed on Lawrence Ave. from Clark St. to Western Ave., except that the old concrete foundation was brought to grade with another layer of concrete. The roadway of Morse Ave. from Ashland Ave. to Sheridan Road was widened from 30 ft. to 48 ft. In this case the old pavement was asphaltic concrete and was entirely salvaged, a new layer of sheet asphalt being placed on top of the old pavement. The roadway of 63rd St. from Ashland Ave. to Western Ave. was also widened. In this case, the foundation under the old brick pavement was deemed not worth salvaging and was replaced with 8-in. concrete.

In these modern days we often hear the city planners of the past severely criticized for planning streets and roadways which are now inadequate to meet the demands of traffic. In answer to this, it may be mentioned that not so many years ago an engineer of national reputation, and a member of this society, criticized the city of Chicago for wasting money in the construction of roadways unnecessarily wide. I have no doubt that the facilities for traffic being provided now will not be adequate 25 years hence. We only build for the needs of the present, partly because of limited finances, and partly because of inability to gauge the needs of the future.

New Portable Ashpalt Repair Plant

A new portable asphalt repair plant has been brought out recently by the Chausse Oil Burner Co., Elkhart, Ind. This new Model E-3 plant is the result of development through a period of three years with Model E-1 and Model E-2 machines. It is a mechanically operated machine with rotary sand drier, pug mill mixer, oil burners and measuring devices, all of which elements are found in stationary plants. In addition, however, are features of self-propulsion on rubber-tired wheels and storage bins for material, which make this machine an independent unit for use directly where repair work is being done.

The Model E-3 plant is equipped with Continental Red Seal 4-cylinder engine which drives the rotary sand drier, and pug mixer and furnishes propulsion through hardened roller heavy duty chain, temper rim sprockets and individual clutches. The plant has a small Kellogg air compressor for fuel line pressure, S. K. F. ball bearings on the sand drier, high pressure lubricators on all other bearings, Cotta transmission, Twin-Disc clutch, Geneva wheels and Standard solid rubber tires. The body of the machine was designed by structural engineers and all steel channels and plates are reinforced with hot riveted and welded members.

The manufacturers rated capacity of the Model E-3 Chausse plant is as an easy 150 sq. yd. of 2 in. compacted mix per 8 hour day, but it is stated it will operate economically a very small output or produce a considerably increased amount without harm to the mechanism.

Reclaiming old asphalt during the operation of the machine is a valuable feature, if desired. It can be cut from the street, loaded into the sand drier, heated to 350°, agitated in the mixer, new asphalt added and returned to the street, thus providing a marked economy in patching costs.

A tool heater, with oil burner, is located at the rear of the machine for heating rakes, tampers, shovels and smoothing irons.

In the machine is bin storage for 135 gal. of asphalt, 2¼ cu. yd. of mineral aggregate, 18 bags or 1,750 lb. of lime dust or cement, and tanks to hold 60 gal. of kerosene and 9 gal. of gasoline. The weight of the machine with tanks and bins empty is 9,400 lb.

New Portable Asphalt Plant in Use by Lincoln Park Commissioners, Chicago

In operation the machine can be loaded at a central storage yard and should be towed to the location of the work. Thereafter it will propel itself at speeds of 4 to 5 miles per hour. If the material in the storage bins is used up, it can be replenished and the machine operation continued without interruption.

The feature of measuring devices for all material and the mechanically operated mixer enables the operators to determine the formula desired.

Highway Bridges

Practice in Massachusetts Outlined in Paper Presented Before Highway Section of Boston Society of Civil Engineers

By ALBERT E. KLEINERT, JR.
Assistant Engineer, Massachusetts Department of Public Works

The development of the motor vehicle has created a strong demand for roads and bridges which are capable of carrying heavy loads and fast pleasure cars. After considering the 2,000 or so highway bridges in Massachusetts, one must form the conclusion that many must either be rebuilt or replaced before this demand is met. This is the work of the bridge department of the division of highways of the Massachusetts Department of Public Works, and includes briefly the inspection and investigation of existing bridges, the design for their reconstruction when advisable, the design and supervision of construction of all new state highway bridges, advice to towns on bridges within their jurisdiction, and the approval of all designs for highway bridges made by private engneers for cities and towns. Included, also, are the designs for structures in connection with highways, such as culverts and retaining walls whenever the same are other than standard.

No existing bridge is replaced until it has been inspected and studied to see if it cannot be reconstructed in some manner to enable it to meet the present-day requirements. However, the usual result of such an examination favors a new bridge. There are several reasons for this. The first is probably the condition of the structure; the second is that the original design was for lighter loads; the third may be that the approaches were safe for the days of horse-drawn vehicles, but are entirely unsafe for motor vehicle velocities; and the fourth, that it may cost more to repair and reconstruct the old bridge than it would to build a new one; and so on. Thus there are numerous reasons for replacement.

In planning a new bridge, certain desirable features should be kept in mind. The line and grade are sufficiently important to receive much attention. If at all possible the bridge should be on a tangent. The grade is best when it is level, or is a continuation of the grade of the approaches. Of course there are cases when ideal conditions cannot exist, such as the elimination of a grade crossing for a railroad where it is necessary to allow at least an 18-ft. clearance over the rail, or where a river has considerable ice during the spring floods and it is necessary to clear these floods, or where it is impossible to cross a river without a curved alignment due to the existence of high embankments above the road on both sides of the river. Bridges have been built on curves, but not until the engineers were convinced that nothing could be done to prevent it. The material to be used for the construction of the bridge is often a cause for study.

For Massachusetts practice, reinforced concrete is usually used for spans up to 50 ft., and steel for spans greater than this. Somewhere near this length the economy of concrete, due to its very low maintenance cost, is offset by the increased initial cost resulting from its own weight. Low maintenance and permanence are the two outstanding advantages of concrete, which have made it so popular as a material for highway structures.

Reinforced Concrete Bridges for Spans Under 50 Ft.—The ordinary design for a reinforced concrete bridge with less than a 50-ft. span, consists of a number of parallel T-beams supported by the abutments. The flanges of the beams form also the floor slab. A curb from 10 to 12 in. high is poured integrally with the slab and beams along both sides of the bridge. This curb serves as a base for the fence which is poured later, or, as is sometimes done, the panels of the fence are pre-cast and placed between the posts at a later date. For a wearing surface a 2-in. layer of the Massachusetts Specifications Type "D" bituminous concrete is the prevailing custom, because of its light weight and its excellent wearing qualities. To use a gravel fill and a surface of bituminous macadam adds over 100 lb. per square foot of dead load to the structure. This seems an unnecessary addition when there is available an entirely satisfactory surfacing at a much less weight. It is a practice to waterproof the floor surface before adding the wearing surface. This tends to keep the concrete dry, or at least prevents excessive changes in the moisture content. The simplicity and efficiency of this T-beam type of concrete bridge have been proven by the popularity it is having.

In some of the rural sections of the state, small bridges are often necessary along roads carrying only local traffic. To meet the demand for replacements here, a flat slab is used for spans up to 15 ft., and steel beams supporting a flat slab are used for longer spans. These are economical because local labor may be called upon to carry out the construction, since the forms are simple to build, and the I-beams are not difficult to place. Concrete curbs 10 to 12 in. high on each side of the bridge support the fence, which for these types is either entirely of wood or wooden rails on iron uprights. Frequently the abutments require but little new construction, and all that is necessary is a new concrete parapet about 12 in. high to support the end of the bridge slab.

Steel Bridges for Spans Over 50 Ft.—Steel bridges for spans over 50 ft. may be divided into three groups,—the plate girder, the pony truss, and the through truss. Plate girder bridges have been used for spans up to 90 ft. Railroad underpasses or overpasses usually are surrounded by conditions which are best met by the plate girder bridge. Several of the recent bridges carrying the highway over a railroad have required a minimum depth for the floor system. To meet this demand plate girders were used with a floor system made up of heavy rolled sections spaced from 3 ft. to 6 ft. on centers, for floor beams without stringers. One of these bridges, with the girders spaced 44 ft. 8 in. apart, had the grade of the road 22 ft. 6 in. above the top of the rail, with a railroad clearance of 18 ft. This leaves 4 ft. 6 in. from the bottom of the concrete protection for the girders to the top of the center line of the road. The saving on the fill for the approaches more than offsets the cost of the additional steel used for the bridge. Some railroads require a concrete protection 3 in. thick on all vertical surfaces and 4 in. thick on horizontal surfaces. It is readily seen that this requirement adds considerably to the dead load of the structure.

Pony truss bridges have been used for spans up to 120 ft. Like the through-truss highway bridges, their design has been very much like the standard truss highway designs. One variation worth nothing is the concrete slab floor. All new steel bridges have a reinforced concrete slab floor spanning from stringer to stringer. A 2-in. Type "D" bituminous concrete surfacing is the common wearing surface. This floor and surface weighs much more than the old wood planking, but the additional weight is unquestionably worth the extra cost.

Among the types of bridges which are less frequently built are the reinforced concrete arch, the pile trestle, and the wooden truss. The concrete arch requires a foundation which is capable of resisting a horizontal thrust of considerable magnitude. Unless a material such as ledge is available for a foundation, the cost of building a rigid support for the arch makes the total cost of the bridge uneconomical, and other types are chosen. A second obstacle in the path of the designer who is partial to arches is the ever-present skew. There are few highway bridges in Massachusetts which have abutments at right angles to the superstructure. The angle is usually from 80 to 40 degrees, and averages about 60 degrees. This condition, of course, adds to the difficulties of design, and likewise to the cost of the bridges, due to the additional length of the abutments.

Types of Abutments.—Two types of abutments are in vogue at present; one is the gravity and the other the reinforced concrete. They are used in accordance with the dictates of economy.

Up to heights of 14 ft., the gravity type is most frequently more economical; higher than this reinforced concrete walls show a saving. Boulder concrete is used for the gravity wall and is, of course, much less expensive than the 1:2:4 mix specified for the reinforced concrete. In cases where the wall is subject to tidewater, a granite facing is necessary for that section of the wall which is alternately wet and dry. The salt water reacts upon concrete between high and low water, and granite is the best form of protection now known to prevent the deterioration of the concrete. The facing makes it advisable to use a gravity wall, for the reinforced concrete wall is seldom thick enough to take a facing. There are two methods of designing the reinforced wall: The first is the cantilever or T-wall; the second is the counterforted wall. The latter has the advantage of greater rigidity; the former is more economical because of more simple forms. All the walls described above have been used for abutments, and it is difficult to exclude any one of them from consideration when determining the type of abutment to design.

Reconstruction of Steel Through-Truss Bridges.—It has already been stated that the usual result of an investigation of an existing bridge, favors a new one. The bridges which prove to be worth reconstructing are the steel through-truss bridges. These were designed for a uniform live load or for a single concentrated live load, depending upon which gave the worse condition. Naturally the uniform load produced the maximum stresses in the trusses, and sometimes in the floor beams. When the stringers were designed, the concentrated load governed, and it is here where most of the trouble lies. The concentrated load of 25 years ago was usually a steam roller weighing abolt 15 tons, 9 of which were on the rear axle and 6 on the front. If the load on the rear is divided equally between the rear wheels, there will be a load of 9,000 lb. on each. Designs to carry the auto truck of today are figured upon 20-ton trucks, of which load 40 per cent is considered as concentrated upon each rear wheel. This amounts to 16,000 lb. and when compared with the 9,000 lb. for which the stringer has been designed, we may readily understand why this member is light. The other members of the bridge are frequently strong enough to carry the loads without excessive fiber stresses. The method of reconstruction, then, is to replace the entire flooring and stringers with stronger designs. This calls for heavier stringers, new yellow pine spiking pieces, new yellow pine sub-flooring 4 in. thick, a waterproofing covering, 3-in. wood block, new yellow pine wheel guards, and other miscellaneous accessories. All wood used must be treated with creosote. All steel parts of the structure receive a thorough cleaning and painting before being covered over with the new floor. Care must be taken to see that the increase in the dead loads due to this new construction does not unreasonably reduce the live load capacity of the structure.

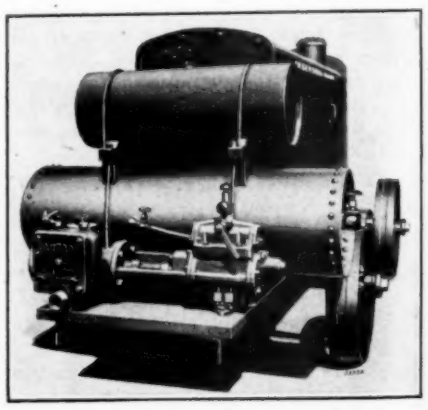
It must be kept constantly in mind that the total capacity of the bridge is constant, and that an increase in the dead load produces an equal decrease in the live load. It is this limitation which prevents the use of a reinforced concrete slab for a floor on our old bridges. Wood block is used instead, because of its light weight. However, there are certain drawbacks to its use. Care must be taken to see that the blocks will remain in place. Excessive stringer deflections and floor vibrations will cause trouble and ultimately ruin the surface. It is wise to keep the deflection as small as possible. No trouble has been reported so far in the case where the deflection was computed to be 1/720 of the span, and this is a good maximum limit to have. Vibration may be reduced by making the structure as rigid as possible. A step in this direction is to frame the stringers into the floor beams instead of supporting them on top. With deflection and vibration provided for, the laying of the wood block is similar to the standard practice for this surfacing. Expansion joints of bituminous materials are placed longitudinally along the edge of the road. A similar joint is placed transversely about every 100 ft. When the span is a long one, a small angle iron reaching from curb to curb is bolted to the sub-floor, with the upright leg just below the tops of the blocks. These are placed about every 30 ft., and prevent the crawling of the blocks in the direction of the traffic. If the blocks are held in position no trouble may be expected. Several bridges have been repaired and resurfaced with wood block within the past few years, and so far this method has been considered successful.

Continuous Bridges.—There is a growing tendency toward the design of continuous structures for highway bridges. Continuous beams for two and three spans are being used. Their economy is established. The types having the abutments continuous with the superstructure have not been accepted and built as yet in Massachusetts, other than for a few short spans. There is still much to be done in developing these designs, but it is only a matter of time before we may benefit from their advantages.

The architecture is also receiving its share of attention. Improvements have been made in the appearance of the bridges. The most noteworthy is, perhaps, the adoption of the so-called "open-work fence." Instead of the old solid panel, the new panel has a series of openings 6 in. wide by 2 ft. high, with a semicircular top, spaced about 12 in. on center. The idea has been to improve the appearance of the bridge without spending extra money. What kind of bridges will be built 25 years from now is difficult to say; but we do know that remarkable advances have been made during the past 25 years, and that there is still room for further improvement.

Portable Compressor-Pump Outfit

A new combined portable air compressor and water pump outfit has been placed on the market by the Ingersoll-Rand Co., 11 Broadway, New York. It consists of a standard Type Twenty gasoline-engine-driven portable compressor and a Cameron air-driven-pump. The outfit is claimed to be particularly suitable for dewatering jobs, and can be used successfully for the elevation of water, for removing the overnight accumulation in ditches and excavations, for cement gun service, and for furnishing water to concrete mixers,



Portable Compressor—Pump Outfit

etc. The portable compressor, in addition to supplying air for the pump, will run such air tools as "Jackhammer" rock drills, paving breakers, clay diggers, portable hoists, drill steel sharpeners, etc.

The pump is mounted on the frame of the compressor adjacent to its source of power. The pump is positive in action, starting up just as soon as the air is turned on. It requires no priming and will handle very muddy water. It can also be regulated to any desired capacity within its maximum rating by adjusting the amount of air admitted.

Several sizes of these compressor-pump outfits are available. It is also possible to obtain the pump alone, together with all parts necessary for attaching it to any Ingersoll-Rand portable now in the field.

Finding Those Old Monuments

Points Worth Remembering When Working From Previous Surveys

By F. O. NELSON
Engineer and Surveyor, Toledo, Iowa

Finding satisfactory evidence of the correct location of property lines when surveying property lines or public improvements on streets and roads is increasing in importance as land values increase, and presents increasing difficulties with the passage of time obliterating original monuments or other markers. In making such surveys, method, persistence and luck all play important parts in the success of those who must search for the markers left by former surveyors. A common sense respect should be held for the work of the early surveyors and for accepted property lines.

We have found that it is an excellent practice to make a thorough search, before going into the field, of records of former surveys that may be on file. When beginning a survey in a town and city addition, it is also a good idea to look up the records of monuments and measurements in all adjacent plats, for while such data is not directly permissible as evidence as to the location of points sought, it frequently affords good starting points from which to measure toward the ones sought. They also establish a boundary in the absence of monuments or witnesses in the tract being surveyed. In such cases they cannot practically be disputed or disregarded.

Follow Established Lines.—When there are no recorded or otherwise recognized monuments in a given addition, such improvements as sidewalks, fences and buildings, and their relative locations, may, by careful study, be used to get satisfactory results.

The surveyor who disregards lines established by early surveys or by the agreement of the owners, and who insists on running new lines from distant points, may cause an inexcusable injury to the property owners and may lose valuable friends. (It is sometimes better to adjust the plat instead of the property lines, for the plat is a record of the lines, instead of the lines being a record of the plat.—Ed.)

Digging for Monuments.—Iron, stone or brick monuments are easy to detect when struck with a spade or other implement used in searching for them. Wood stakes, after but a few years' service, may be cut so easily with a spade that their presence may not be noticed unless the dirt is removed so that they are visible. Limestone and soft brick may also be largely decomposed, but can be identified. Care is needed in deciding upon the work found. For example—we have found stones which, at first glance, appeared to be the recorded stone, but which turned out to belong to an old foundation or other buried structure. Another time we found a farm corner stone standing in the usual upright manner, which would usually have passed for the true corner, but investigation revealed the absence of the brick which the record said was placed beneath it. The brick was found several feet away, deep in the ground, and in line with other corners.

Searching With Persistence.—The persistence with which the search for lost markers should be continued will be based ordinarily upon a more or less meritorious guess. It is sometimes evident that a monument has been destroyed by road work or ditches, so that there is no use in digging. Witnesses or a resurvey must be relied upon. We find it well worth while to keep up a search with spades in most cases where there has not been much soil removed.

Where soil has accumulated by wash or a fill, the search will usually prove worth while. The amount of such accumulation by wash in the neighborhood of hilly land is apt to be underestimated. It is often difficult to tell by the appearance of the soil when the original level has been reached. We have found a stone over four feet in the ground in a valley, with no indication that it had originally been set in a depression. It was found and positively identified in spite of surveys to nearby corners that did not check properly. Fences that did not correspond, and discouraged diggers; and there was great joy over that which had been lost.

Another stone had been practically given up as lost. Search had been made over a reasonable area. But a farmer thought that he would dig a little more while we did some other work nearby, and found the stone. The distance to a railroad a few rods away did not check with the records by several feet. In another case we found a corner stone in a plowed field a rod or two from a line fence. Here we were guided by measurements from other corners.

Unrecorded Monuments.—Many times it is found that a previous surveyor has placed a monument without recording it. When they check with other points, or are properly identified by someone with personal knowledge of them, the surveyor may well feel lucky. They are a source of information that is not directly the result of skill, yet the practice of inquiring about their existence of property owners who may know about them should be adhered to. The same principle should govern in finding fence lines and other improvements that mark boundaries.

To the beginner I would say, do not think that you have a point practically located when a neighbor says, "Yes, I can go out and show you where that stone is." He often finds that his memory is at fault. Even when he points out a mark or a spot that he is sure of, it is well to check it up as well as conditions permit.

Poor Memory.—The point he indicates may be where a flag on an offset line was used by a previous surveyor. Many times, however, this sort of help can prove very valuable. Once a farmer came across his field to voluntarily point out the location of a stone. It was right beside a corner post, just where one might expect to find it, but so deep in the ground that we would probably have dug over a large area before going so deep.

Errors in Records.—Errors in the records are a source of a great deal of trouble. They may be revealed, in part, by careful examination and by comparison with other records. Some consider it luck to be able to grin and bury them, and to a limited extent they are justified in this attitude.

Too much attention to very small errors costs the man who pays the bill more than the time thus spent is really worth, and will rather tend to increase the danger of making bigger errors. Errors that may have been of but little consequence when the value of the property was low may now be serious matters with the high values of today and of the future.

Thoroughness and permanence are therefore in order.

Gold Medal Awarded Paver Manufacturer

A gold medal and testimonial in recognition of 25 years of service to the road building industry, and to the public, has been warded to The Foote Company, Inc., Nunda, New York, by the American Institute of New York.

The American Institute was founded in 1828, and its exhibitions have been widely attended for almost a century. Horace Greeley, Whitelaw Reid, James Gordon Bennett, Henry Ward Beecher, Ezra Cornell, who was the founder of Cornell University, and other famous men have headed the institution during its history. Among the outstanding inventions awarded the gold medal during the past years were the telegraph in 1842, the wire rope of John A. Roebling and the Howe and Singer sewing machine in 1846, the McCormick reaper and binder in 1849, and the Bell telephone and Royal typewriter in 1873. Although the award is made by the Institute, it is empowered and paid for by the state.

Vermont Plans to Spend $1,075,000.—The state highway commission of Vermont has asked for $1,075,000 to carry on its maintenance work during 1927. The recommendations also listed $450,000 for state aid to towns, $100,000 for state aid on bridges, and $125,000 for supervision and engineering expenses.

Sidewalk Snow Removal

A Trackson-equipped Fordson with a New Englad sidewalk plow is used by the city of Old Forge, N. Y., to keep its sidewalks free from snow, and is stated to have proved to be a very efficient and economical unit. It is said to do the work much faster than men with shovels or horse-drawn equipment can do it, and goes through drifts of 3 ft. without difficulty.

The tractor is equipped with the new narrow model Trackson Full-Crawler, which is narrow enough to permit the outfit to go between embankments, ter-

Sidewalk Snow Removal with Tractor and Plow

races, posts, etc. The crawler is equipped with snow grouters for extra traction.

It is stated the unit can be operated over curbings as high as 10 in., and that it travels at a speed of about 7 miles an hour.

The sidewalk plow is manufactured by the New England Structural Products Co., Everett, Mass., and the Trackson Full-Crawler is made by the Trackson Co., 500 Clinton St., Milwaukee, Wis.

Pit Move, a New Stem in Specifications

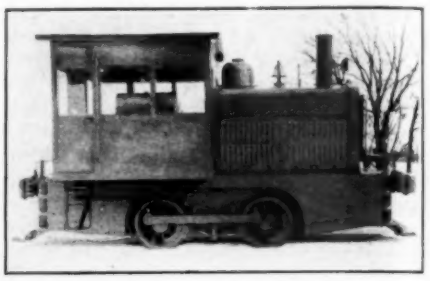
According to J. E. O'Neil, construction engineer, North Dakota Highway Dept., in the North Dakota Highway Bulletin, gravel pits in that state do not contain very uniform material, as they contain sand and clay pockets and it has been found practically impossible to determine the exact amount of road surfacing material in a pit. After a pit has been thoroughly tested and the estimate of available material made, it has sometimes been found on construction that the quantity of material called for in the estimate was not available. This resulted in a move oft-times to a pit not shown on the plans and, although this was amply covered in the former specifications, it sometimes resulted in more or less dissatisfaction on the part of the contractor and increased the risk to the contractor bidding on the gravel work. In order to protect himself, it was necessary for him to submit a higher bid than otherwise. To eliminate this risk the North Dakota Highway Department has incorporated in their specifications an item known as "pit move." The following quotation is taken from the specifications: "The item of pit moves shall be construed as moves to one or more pits not designated on the plans on file, providing, however, that a deduction will be made on unit price bids paid for moves contemplated on the original plans but not made. Payment for the item of pit moves will be made for the net moves as made by the Engineer in writing, which shall be the total number of moves made on any project less the number of moves contemplated in the original plans on file. No allowance shall be made for moves within the same pit. The price shall include the building of such roads as may be necessary to reach the pit from the project and the maintenance necessary to keep and leave the dead haul in as good a condition as when hauling started." As the number of such moves in constructing a project cannot be anticipated, this item is carried as a nominal quantity.

May Change Texas Highway Law.—Legislation has been introduced in the Texas state legislature that would make the office of highway commissioner elective instead of appointive. No change would be made in the number on the commission, but the salary of a commissioner would be $6,000 a year instead of $2,500, while the bond would be fixed at $10,000. Terms would be overlapping, with the first elective commissioners serving two, four, and six tion would be held in November, 1928.

30-Ton Gasoline Locomotive

The Dupont Rayon Company recently purchased a 30-ton gasoline locomotive from the Geo. D. Whitcomb Co., said to be one of the largest gasoline haulage tools that has ever been built, with the possible exception of a type for experimental purposes.

This locomotive is powered with a 6 cylinder 6½x7 Beaver engine, capable



30-Ton Gasoline Locomotive

of developing 160 hp. at 1,000 revolutions per minute. It has a draw bar pull of 17,500 lb. on low gear without sand.

The frame is of solid type construction, axles of forged steel, and wheels with chilled tread, or of any type required by the purchaser. Transmission allows for all speeds, either forward or reverse, and sand is furnished at all four wheels.

Motorbusses in the United States.—There are now approximately 80,000 motorbusses in use in the United States. Of this total 15,332 are used by consolidated schools for transporting pupils; 7,000 are used by 344 street railways, and 510 are used by 41 steam railroads.

New Trade Publications

The following trade publications of interest to highway officials, engineers and contractors have been issued recently. Copies of them can be obtained by addressing the firms mentioned:

Traffic Markers.—The National Traffic Appliance Corporation, Chicago, has issued a booklet describing the advantages and use of N. T. A. Traffic Markers, the metal button that has already come into extensive use in Chicago and in other cities. This type of marker is used in place of painted lines, and is said to be more effective than the older marking system.

Tractors.—The Monarch Tractors Corporation, Springfield, Ill., has just issued a specification folder on their new 6-ton Model H Tractor. This machine, a track-type machine powered with a 4-cylinder 60 brake H.P. motor, has been especially designed for road builders. The same company makes a 10-ton tractor for heavier duty.

Trucks.—The Indiana Truck Corporation, Marion, Ind., has issued an interesting booklet and interesting folders telling about their road building and contractors' trucks. The literature gives complete specifications and cites by letter and illustration many successful jobs on which their trucks were used in hauling materials or batches of concrete. An interesting model shown is their Model 111-X, a road builders' truck with a capacity of 1½ cu. yds.

Concrete Mixers.—The Construction Machinery Company, of Waterloo, Iowa, is distributing a new catalog of their line of tilting concrete mixers. These building mixers have a number of interesting features, and are built in sizes ranging from the little 3-S to a 14-S machine. The same concern supplies backfillers, hoists and pumps in various sizes and models.